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(This completes Vol. 8)

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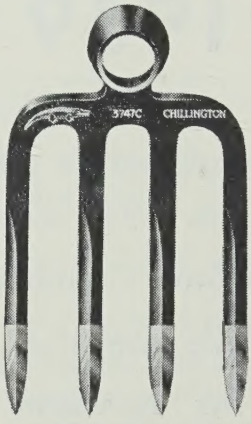

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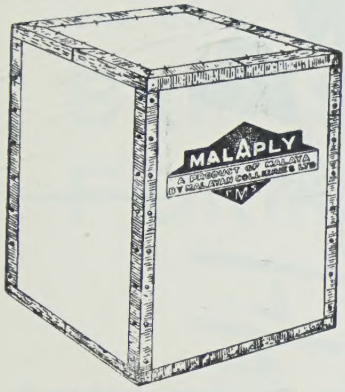

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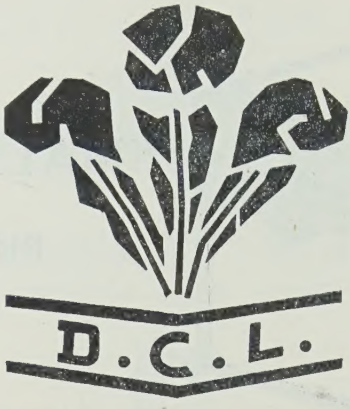

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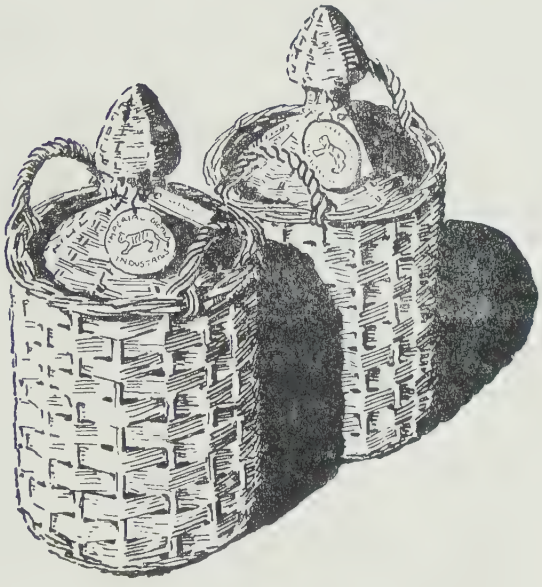

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THE RUBBER RESEARCH INSTITUTE OF MALAYA

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THE RUBBER RESEARCH INSTITUTE OF MALAYA

The offices and laboratories are situate at the 3rd mile, Ampang Road, Kuala Lumpur. The postal address is P.O. Box No. 150, Kuala Lumpur, and the telephone is Ampang 47 and 48 (two lines). The telegraphic address is "Searching, Kuala Lumpur."

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It is notified that at the request of their employers a few Conductors who are already in employment on rubber estates may be received at the R.R.I. Experiment Station for a short course of training of about one week during the month of January 1939.

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Corrigendum

Journal Vol. 8 no. 2 page 137

The *headings* of the two right-hand columns of the table should be transposed and amended, so that the heading of the last column reads "1 oz. Ca. arsenate/1 lb. Bran."

JOURNAL

OF THE

RUBBER RESEARCH INSTITUTE OF MALAYA

VOL. 8 NO. 3 NOVEMBER 1938 NO. 23 OF THE SERIES

EDITORIAL

EFFECT OF *Lalang* ON THE GROWTH OF YOUNG RUBBER TREES

The undesirability of the presence of *lalang* on rubber estates is generally recognised, no less in these times of cover plants than in the days of clean-weeding. A paper in this issue describes the results obtained from experiments started jointly with the Department of Agriculture, at Serdang and at Klang. Although they have not elucidated the causes of the big retarding effect which *lalang* has on the growth of Hevea, they have provided striking measurements of the extent of that retardation. At five years after planting the girth of the trees grown on clean-weeded or leguminous cover plots was about double that of the trees on the *lalang* plots.

OIDIUM HEVEAE

With the "Oidium season" due in the not far distant future, Mr. Beeley's paper reporting on the 1938 outbreak will be read with interest. The attack was a comparatively light one, and once more the weather conditions early in 1938 were such as to reveal another facet of the complex problem of the relation of climatic conditions to the incidence of this leaf-disease. It is fortunate that conditions specially favourable to attack of Hevea by the fungus seem to be comparatively rare in Malaya, for Mr. Beeley's conclusion is that the fungus may be present in a dormant condition over large areas, only to break into active and virulent attack if favourable conditions supervene.

TAPPING EXPERIMENTS

The results for the earlier years of the Seventh Mile Estate tapping experiment have been reported and discussed in recent issues of this *Journal*. In this issue Mr. Sharp reports the results

for the fifth and final year of this experiment, which has now been discontinued. These results confirm those obtained in earlier years, and need not again be discussed here. A full account of the whole experiment will be published in due course as a separate memoir. A comprehensive series of new tapping experiments, following on from the Seventh Mile experiment, have been started in 1938.

Mould Growth during Storage of Sheet Rubber

Now that it is permitted to carry bigger stocks of raw rubber on estates, the question of the best storage conditions becomes of greater importance. Risk of mouldiness is the most serious danger. The paper by Messrs. Hastings and Piddlesden, of the Chemical Division, on "Prevention of Mould Growth on Sheet Rubber during Storage" is thus of topical interest at the present time.

The Ideal Smoke-house

The ideal smoke-house would be one in which sheet is dried quickly with adequate smoking as contrasted to mere drying, with a minimum of handling, and of fuel consumption. The new R.R.I. tunnel-type smoke-house, as described by Mr. Piddlesden, of the Chemical Division, in the paper entitled "Experiments with a New Type of Smoke-house" is a much nearer approach to this ideal than any type previously developed.

Dangerous Bale-Strapping

A timely warning is issued by Dr. Rhodes, of the danger of using copper-plated bale-strappings for raw rubber. Contamination of rubber with copper has serious effects on the quality of articles manufactured from it.

Plasticity and the Colour of Sheet Rubber

The paper by Mr. Hastings on the plasticity and colour of sheet rubber was presented at the Rubber Technology Conference of the Institution of the Rubber Industry in London in May last. Mr. Hastings's results lend little support to the opinion of many manufacturers that light-coloured sheet is harder than dark-coloured sheet. It appears that this may be so sometimes, but by no means always; and that the manufacturer buying sheet in the open market may be as likely to obtain a hard rubber by a random choice among dark as he is among light sheet. Further work on this subject is needed.

The Constituents of Hevea Latex

Several papers on Dr. Roberts's work on the analysis and composition of Hevea latex and of raw rubber have been published in this *Journal* during the past three years. In this issue are reprinted two papers by Dr. Roberts, published originally in the *Journal of the Chemical Society* earlier this year, dealing with the method of separation and isolation of the constituents, and, from the chemical point of view, with the bearing of his results on the problem of the intermolecular structure of rubber.

Latex Preservatives

The search for an efficient and economic alternative to ammonia as a preservative for latex continues. The paper by Dr. Rhodes in this issue describes very promising results that have been obtained with "Santobrite" (Sodium pentachlorphenate). Although its use as an entire substitute for ammonia is not to be advocated, it can be used to advantage with amounts of ammonia very much less than those necessary if ammonia alone is used.

A Visit to Indo-China

It is particularly desirable that technical workers on rubber products should know something at first-hand of the conditions and problems obtaining in neighbouring rubber-growing territories. Mr. Piddlesden's report on his visit to Indo-China contains much that will be of interest to Malayan rubber-growers, restricted necessarily, in the main, to the organisation and operation of estate factories in Indo-China.

Creaming Latex

The work of Dr. Rhodes and Mr. Sekar on the use of creaming agents for latex-concentration has resulted in two British patents the specifications of which are reprinted in this issue. They concern the use of a synthetic chemical ("Sulphonated Lorol") and a natural product (Tamarind Seed Powder). These patents will be registered in the Straits Settlements and the various States of Malaya, in pursuance of the policy of preventing the results from being patented by any commercially interested party, and so as to render them freely available for the use of the industry.

Book Reviews

Among the book reviews in this issue is an article on Soil Erosion, covering several recent publications on this subject of world-wide interest.

Courses of Instruction for Estate Conductors

The increasing extent to which estate managers are availing themselves of the opportunity for training of conductors at this Institute's Experiment Station has made it necessary to define more precisely the arrangements for such training, as announced in the notice preceding this Editorial.

Kuala Lumpur,

24th November, 1938

THE EFFECT OF *LALANG* ON THE GROWTH OF YOUNG RUBBER TREES*

The harmful effects of *lalang* on various forms of cultivation are well known. In 1931 experiments were commenced with the object of determining the cause of these effects. Two experimental areas were selected, one at the Government Coconut Experiment Station, Klang, and one at the Central Experiment Station, Serdang. Both areas were at the time under heavy *lalang*, and were then planted with rubber trees.

Three types of cultivation treatment were given at each area, *viz*: (a) *lalang* retained: (b) *lalang* removed and leguminous creepers planted: (c) clean-weeded.

Soil samples were taken at approximately quarterly intervals, and analysed by the Soils Division, Rubber Research Institute. Growth measurements were also recorded.

Experimental Details

A. Serdang Area

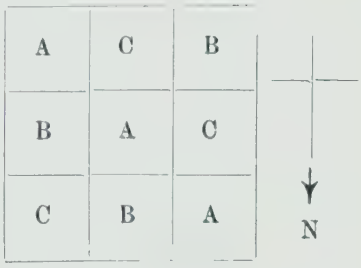
1. *Plot Lay-out.* Nine plots, each half-an-acre in size, were laid out on undulating land which had been cleared from jungle in 1922, and had subsequently been abandoned. The soil is a quartzite loam. A Latin Square lay-out was adopted.

2. *Cultivation History*

Treatment A = *Lalang* retained

B = *Lalang* removed, *Centrosema pubescens* planted and no other covers permitted

C = *Lalang* removed and clean-weeding adopted.



Basket seedlings were planted in late October 1931, but owing to excessive rat damage the whole area had to be replanted in

* The experiments here described were arranged and conducted jointly by the Department of Agriculture, S.S. & F.M.S. and the Rubber Research Institute. The results obtained with coconut palms have been published in *The Malayan Agricultural Journal*, Vol. XXVI, No. 9, September 1938, p. 369.

May 1932, using stumps. In the plots under *lalang*, 4-feet wide circles were cleared, in which the young rubber seedlings were planted, and these circles were maintained until 1935, when they were reduced to 3 feet. The circles were weeded every two months.

Contour draining was put in on the clean-weeded plots, and in 1933 this was extended to all the other plots. During 1933, on one-half of each *lalang* plot, a scheme of six-monthly slashing was instituted.

By 1937, the Centrosema cover had almost completely died out, presumably owing, in part at least, to the heavy shade, the stand not having been thinned-out, and the plots under this cover were then scarcely different in appearance from the clean-weeded ones.

B. Klang Area

1. *Plot Lay-out.* Twelve half-acre plots were laid out on flat coastal clay soil in the form of four blocks, of three plots each.

The water-table is high, varying from 12 inches to 36 inches (approx.) from the surface. The land was cleared between 20 and 30 years ago and was cropped with sugar, paddy and tapioca, whilst during the last 12 years (until 1931) it had been under *lalang*.

2. *Cultivation History*

Treatment A = *Lalang* retained

B = *Lalang* removed and *Centrosema pubescens* and *Calapogonium mucunoides* planted.

C = *Lalang* removed and clean-weeding adopted.

B_1	C_1	A_1	B_2	C_2	A_2
C_3	A_3	B_3	C_4	A_4	B_4

The removal of *lalang* was accomplished by changkolling and forking to a depth of 6 inches.

Each plot was surrounded by a 3-foot drain, which marked the plot boundary.

Basket seedlings were first planted in October 1931, but owing to heavy rat damage replanting with stumps had to be done in May 1932. During 1933, on half of each *lalang* plot, six-monthly slashing was adopted. The 6-feet cleared circles around the rubber plants were retained in each *lalang* plot until 1935, when they were

Sub-plot 1a : Lalang
(Trees 4 years old)

Sub-plot 2b : Cover.
(Trees 4 years old)

Sub-plot 1c : Clean weeded
(Trees 4 years old)

reduced to 3-feet diameter. The circles were weeded every two months.

The leguminous cover was difficult to establish and in 1933 was replanted, using *Centrosema pubescens.*

Soil Analyses

Top-soil and sub-soil samples were taken by means of augur borings on nine occasions from October 1931 to September 1934, and analysed. The analytical determination included those of pH, carbon, nitrogen, and conductivity as a possible rough index of total "available" soil nutrients. Large fluctuations occurred in the results; these were probably caused by sampling errors, although four to six random samplings per plot were taken. No reliable conclusions can be drawn from the figures obtained, and they are not reproduced.

Soil-moisture determinations were also commenced, but were abandoned owing to the large variation in local conditions which was found to occur at times of individual samplings.

Growth Measurements

The measurements recorded in Tables I and II give heights and spreads in the early years and, later, girths only, of the rubber plants. The measurements are not strictly continuous because the earlier measurements were taken on different trees from the later ones, and also girths were initially at 12 inches height but later at 36 inches height. The last three sets of readings (May 1936 to April 1937) were all taken on the same trees and at the same height. There was no apparent difference between the trees on the halves of the *lalang* plots which were slashed since 1933, and those on the halves which were not. Separate measurements on the two halves were not made.

All measurements confirm that the *lalang* has had a very severe retarding effect on the growth of young rubber, whilst the trees on the clean-weeded plots are not significantly different in girth from those on the cover plots. Thus, at Serdang, the average girth (at 36 inches) of the trees in the *lalang* plots, in April, 1937, when the experiment was discontinued, *i.e.* five years after planting, was only 7.2 inches, whilst the corresponding values for the cover plots and the clean-weeded plots were 15.6 and 16.4 inches respectively; 217 per cent. and 228 per cent. of the value on the *lalang* plots. At Klang the corresponding values were: *lalang*, 9.4 inches; cover, 16.3 (173 per cent.); clean-weeded, 15.8 (168 per cent.) The differences in growth are clearly shown in the three photographs of a typical plot of each treatment*.

* We are indebted to the Agricultural Department, S.S. and F.M.S., for these photographs.

Conclusions

The experiments have done no more than definitely to confirm a widely held view, that *lalang* seriously retards the growth of young rubber trees, and to measure that effect under the conditions described. They have not thrown any fresh light on the mode of action whereby the effect is produced.

It is probable that competition—for moisture and for plant foods—is a major factor concerned, although no valid evidence for or against this supposition can be adduced from the results of soil analyses, owing to the failure sufficiently to eliminate the effects of sampling errors.

TABLE I

Growth Measurements at Serdang

Date	Measurement	Treatment			
		Lalang	Legu-minous Creeper	Clean-weeded	Grass*
November 1932	Height; (feet) ...	3.25	3.9	4.3	4.2
April 1933	„ ...	3.27	6.1	6.05	6.5
November 1933	„ ...	5.2	11.6	12.5	12.1
April 1934	„ ...	6.0	16.25	18.3	16.8
September 1934	„ ...	11.0	22.25	24.3	22.0
	Girth at 36″ ; (ins.) ...	3.3	7.3	8.0	7.0
March 1935	Height (ft) ...	9.4	24.7	26.6	23.6
	Girth at 12″ ...	4.6	10.7	11.9	9.9
	Spread (ft) ...	2.8	9.2	10.0	8.5
September 1935	Height (ft) ...	10.0	29.5	27.9	24.9
	Girth at 12″ ...	5.7	13.3	14.5	12.1
	Spread (ft) ...	3.2	10.5	11.0	9.3
May 1936	Girth at 36″ ...	5.6	12.9	13.9	11.8
October 1936	„ „ „ ...	6.5	14.6	15.5	13.3
April 1937	„ „ „ ...	7.2	15.6	16.4	14.3

* When the experimental area was replanted in 1932, three extra plots in grass were added. The measurements on these plots are not strictly comparable with the remainder, but they are included as a matter of interest.

TABLE II

Growth Measurements at Klang

Date	Measurement	Lalang	Legu-minous Creeper	Clean-weeded
October 1934	Girth at 12″ (ins.) ...	7.4	9.6	9.6
April 1935	Height (ft) ...	16.1	25.2	24.5
	Girth at 12″ ...	9.0	12.1	12.6
	Spread (ft) ...	6.7	11.9	12.2
October 1935	Girth at 12″ ...	9.8	14.0	14.9
May 1936	„ „ 36″ ...	8.0	13.8	13.6
October 1936	„ „ 36″ ...	8.4	14.7	14.5
April 1937	„ „ 36″ ...	9.4	16.3	15.8

OIDIUM HEVEAE

Report on the 1938 Outbreak of Hevea Leaf-Mildew

by

F. Beeley

In contrast to the general failure of the N. E. Monsoon to bring dry weather in the early months of 1937, the present year's weather indicated a strong influence of the Monsoon winds over the period January to March, but with a marked interruption towards the end of January and first week of February. Heavy rains occurred then in the northern part of the Peninsula, and to a less extent in the central and southern districts, causing considerable delay to the wintering of the rubber tree foliage. This delay was so accentuated in the north that the wintering, rather than being two or three weeks ahead, was actually two or three weeks later than that of the southern districts, with the result that the northern States have experienced their worst-known attack of Hevea leaf-mildew. In other respects the wintering was a good one and the most intense seen for many years, large areas being at one time leafless; had it not been for the interruption of the fine weather period there is little doubt that the rubber trees of Malaya would have obtained a fine healthy new foliage.

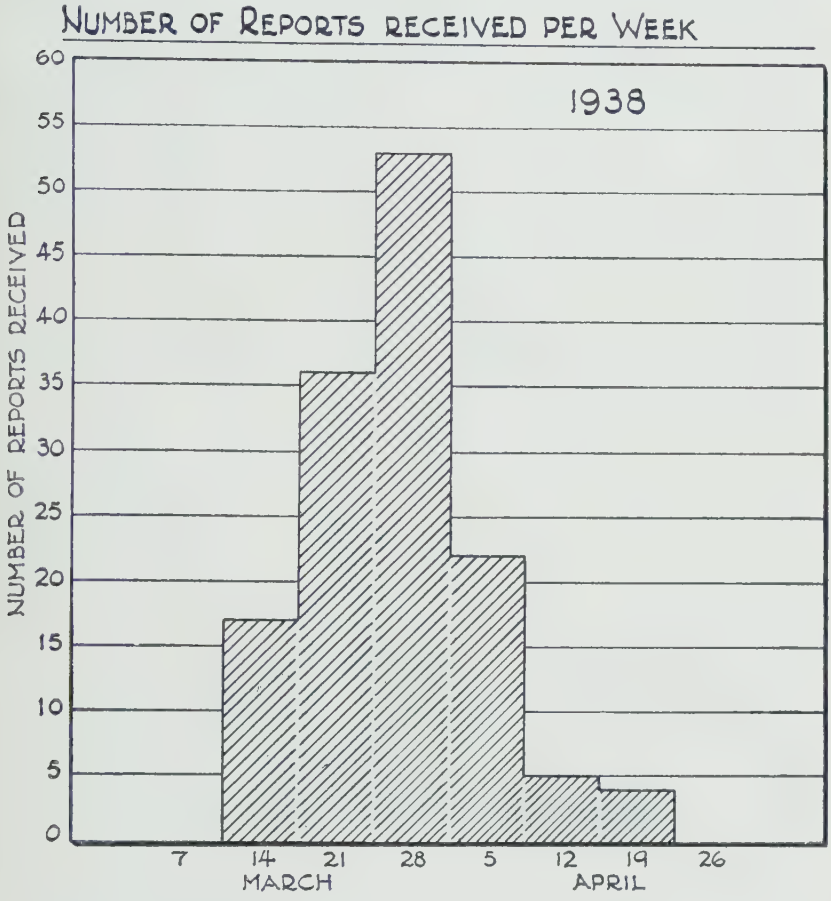
Rainfall figures of central Kedah were: from 1st January to 24th January, less than 1″; from 25th January to 7th February nearly 9″; the dry period from 8th February to 7th March about ½″.

On and after the 8th March, almost sunless days, and light rainfall of the drizzle type, were experienced throughout the Peninsula, as is usual after the termination of the N. E. Monsoon winds.

Thus, with the exception of the short but very decided interruption at the end of January and beginning of February, the wintering season had been very dry, and an excellent fall of old leaf had thus been brought about. The earlier-wintering trees obtained new healthy foliage, but in the case of the north a large proportion of the trees, whose wintering had been delayed by that period of wet weather, were refoliating late enough to be adversely influenced by the dull showery weather in mid-March, with the result that many of them were heavily attacked by the leaf-mildew fungus *Oidium Heveae*.

A survey by air was undertaken on the 2nd and 3rd of March, and the extent and degree of wintering observed in all areas west of the main range. In contrast to the observations made during a similar survey in previous years it was noted that the North

of Perak, Province Wellesley and Kedah were very bare of foliage while South Perak, Selangor, Negri Sembilan and most districts in Malacca and Johore were well advanced in refoliation. It was thus realised that if dull weather occurred in the north the rubber trees in that part of the country would be likely to suffer severe damage by the leaf mildew fungus.



Fortunately the north was favoured by more than a week of fine weather longer than the central and southern areas, which helped the refoliation considerably, but from the 9th of March onwards the mildew attack developed rapidly, causing considerable fall of whole canopies of such new leaf as was in the very young, pendant, waxy, coppery green stage. Leaves which had reached the bright green, rigid, mature state were not attacked.

In the south the first dull day occurred about the 4th of March, and an area of rubber kept under observation, being close to the laboratories, showed prolific development of the fungus *Oidium Heveae* on the young leaves on the 8th idem. Thereafter the lack

of sunshine for the next few weeks slowed up the development of the foliage of the latest-wintering trees, and afforded conditions more favourable to the development of the mildew fungus; some areas suffered worse than others according to local conditions and time of wintering of the trees.

The dull weather interspersed with bright periods also afforded ideal conditions for the development of the Thrips and mite pests of rubber foliage; many reports of the presence of *Oidium Heveae* proved to be in fact Hevea Thrips, mites or spiders and leaf-spot fungi. On the eastern side of the range the rainy period of the monsoon lasted well into January, wintering was consequently later and the drought not so intense as on the west. Although Oidium is present in the eastern rubber areas the conditions seem to have favoured the insect and leaf-spot diseases of the young foliage rather than the mildew type.

Oidium Heveae 1938

Reports Received per Week from each State or Settlement

	March				April				
	1 — 7	8 — 14	15 — 21	22 — 28	29 — 5	6 — 12	13 — 19	20 — 26	Total
Johore ...	—	—	2	3	4	2	—	—	11
Malacca ...	—	—	6	5	—	—	—	—	11
Negri Sembilan ...	—	10	13	16	5	—	—	—	44
Selangor ...	—	4	5	11	3	—	2	—	25
Perak ...	—	2	4	6	6	2	1	—	21
Province Wellesley	—	—	1	—	—	—	—	—	1
Kedah ...	—	1	3	8	2	—	—	—	14
Pahang ...	—	—	—	—	—	1	1	—	2
Total ...	—	17	34	49	20	5	4	—	129

Reference to the table and graph of numbers of reports received shows the time of first-noticed mildew attack in the various States and may be compared with a similar graph and table in the report for 1937. The absence of reports in February and the first week of March indicates the beneficial effect of the bright dry weather. The general break in the weather then caused a sudden short though intense outbreak of Oidium, reaching highest intensity about the fourth week of March, further leaf-

fall ending about mid-April. The increase in the number of reports from north Perak and Kedah is indicative of the situation in those districts.

As in previous years, in early April the writer made a tour by car of the rubber-growing districts west of the main range in order to ascertain the extent and severity of the leaf-mildew disease and quality of the new foliage. He is again indebted to those managers of estates who sent in reports of the occurrence of the disease, and data regarding percentages of trees attacked and local weather conditions, which have helped to formulate the district reports given below.

Johore

The wintering was generally better and more intense than in previous years and much new leaf was obtained before the break in the weather, when observed during the first week of March. Variations in intensity of wintering were observed in foot-hill areas, ravines and in the coastal flats with high water-table, while the northern areas were perceptibly more advanced than the southern parts of the State; certain areas near Gemas and Batu Anam on white sandy soils appeared to carry old green foliage developed late last year following a drought in August. The number of reports of occurrence of the disease is less than half that of 1937.

Early in April the refoliation was well advanced in most parts of the State. In the Tangkak district the new foliage was particularly good and only the latest-wintering trees had suffered slight defoliation in the lower branches. The coastal districts were later in refoliation and the foliage was of a rather mixed character. Even so, comparatively few trees had been attacked.

South Johore also being slightly later had foliage in all stages of development, some of which had been attacked by the Thrips and mites pests as well as to a mild extent by *Oidium Heveae*. The Kluang district was well advanced in refoliation and little mildew was found, though here again the insect pests appeared to be the chief cause of damage to the young leaf.

The Labis-Gemas district showed some excellent new foliage but some trees still carried old green leaf while others were making a partial attempt at wintering, and where new leaf was just commencing both Oidium and Thrips were active.

Young rubber and some manured areas showed greater improvement in foliage this year than last year.

Malacca Territory

Throughout the Settlement the dry weather had induced an early and complete wintering and the great majority of trees had

obtained their new healthy foliage before the break in the weather. In early April about 10 per cent of trees in the southern part of the Territory were incompletely refoliated and had been attacked by the leaf-mildew fungus, causing complete defoliation of a small percentage of those attacked.

Inland east of Jasin the trees had suffered to a much less extent, while the northern districts also appeared to have completed their refoliation with little loss by disease, thus maintaining the improvement noted in previous years.

In the younger rubber, Thrips and Mites were found to be active on the foliage of the new shoots.

Sulphur-dusting carried out in previous years by several estates in this area was deemed to be unnecessary this season, as refoliation was practically complete before the dull weather arrived.

The number of reports of occurrence of the disease, being about half that of 1937, gives some indication of the improvement of the foliage this year.

Negri Sembilan

Throughout this State a good, severe wintering of all rubber trees had occurred, though in early March the flat Linggi district and some of the valleys in the Jehol-Kuala Pilah districts were late and showed both old and new foliage, when in other parts of the State the rubber trees were well advanced in refoliation. In early April the Labu, Nilai, Sepang, Lukut and Port Dickson districts had completely refoliated and had suffered very little leaf fall. Between Seremban and Tampin, though most of the new foliage was in good condition, occasional defoliated trees were observed.

In the Johol, Rompin, Kuala Pilah districts late-wintering of trees in river flats and some steep slopes had enabled the disease to cause defoliation of a small percentage of the trees.

North of Seremban again, a few late-wintering trees caught by the bad weather had been adversely affected, but on the whole the foliage was very good. Some known manurial areas, particularly, had made good progress in refoliation during the dull weather of March.

Many estates in this State had prepared for the usual sulphur-dusting programme but in most cases a shortened programme of two or three rounds of dusting was given, and generally speaking the treatment had been effective in preventing leaf fall in the late-refoliating trees which alone had been subject to attack.

Clonal differences in wintering and refoliation were not so apparent as last year, the drought having been severe enough to cause more even wintering.

Selangor

The wintering on the peat and coastal clay soils did not seem to be so severe as that in the inland districts, consequently a more mixed type of foliage has developed. The trees on the peat soils made a good recovery but the clays and foothill areas suffered a comparatively severe attack of both the leaf-mildew and Hevea Thrips. A rather bright period of weather about mid-March did much towards the recovery of the foliage in this part of the State. As last year, the low hills between the main range and the coast were the scene of the greatest intensity of the disease in Selangor. Nearer the hills, between Kuala Lumpur and Tanjong Malim, most of the trees had obtained their new foliage before the break in the weather, and comparatively few trees, confined to low-lying areas, had suffered from the disease; these were usually attacked only in the lower shaded branches. Good recovery of the affected trees throughout Selangor occurred during the brighter weather of April.

Perak

The districts throughout the line Tanjong Malim to Ipoh had experienced a good, severe wintering generally, and in early April the foliage was in excellent condition, the canopies being so dense as to cause danger to the tapping panel from other diseases. In only a few exceptional cases was a slight leaf-fall observed. North of Ipoh conditions were somewhat similar up to Kuala Kangsar, but to the north-west of this point the influence of the heavy rain in the middle of the dry period became visible, and poorer foliage, with trees partly or wholly defoliated, could be seen in most fields of rubber. Insects of the Thrips and spider type were also active at the time of inspection.

The Teluk Anson, Sitiawan and Bruas districts, as is usual, appear to have had a less severe wintering, and even in April old green leaf, old brown leaf, and new foliage could be observed in the same field. A mild attack of leaf-fall was occurring at the time of the visit, but recovery is now practically complete. Younger rubber and manured old rubber appear to have maintained the foliage growth to good advantage during the dull March weather.

The coastal districts west of Taiping had wintered early and obtained a good, new foliage just before the break in the weather. The areas west of the Gunong Bubu, as is usual, carried trees in all conditions of wintering and refoliation and some fairly severe leaf-fall caused by Oidium and Thips was observed.

Province Wellesley

The situation here is similar to that reported last year; fortunately the rain at the end of January had not been as heavy

as it was further inland in Central and South Kedah and North Perak.

Occasional trees had been attacked by both Oidium and Thrips causing a slight fall of leaf from the lower branches.

KEDAH

In former years little, if any, attention has been paid to the mildew leaf-disease of rubber in this State, but during the present season Central and South Kedah have experienced a heavier attack than any other part of the Peninsula visited by the writer. The older rubber was the chief sufferer, and heavy manuring did not appear to have afforded much protection, such areas suffering as much leaf-fall as unmanured areas. When observed on March 2, the rubber areas were very bare of foliage whereas in previous years the new, green foliage had practically reached maturity throughout the country by that date. Enquiry showed that this delay of the wintering had been caused by the fall of 8″ to 10″ of rain in the period January 25 to February 8, and at a time when an intense drought usually brings about the fall of the old leaf. This heavy rain appears to have delayed the wintering process by two to three weeks and thus many of the trees had foliage in the very young stage, very susceptible to mildew attack, when the dull showery weather began about the middle of March. As a result, a fairly heavy fall of young leaf occurred, especially in the Sungei Patani district and to a less extent in the south of Kedah generally. Bedong and the North did not appear to have suffered very much, indeed the wintering had not been delayed to the same extent as districts further south.

During the first week of April the situation in the Sungei Patani district showed that roughly 5 to 10 per cent of the trees still had not completely wintered, 15 to 20 per cent had suffered loss of the majority of their new foliage, 20 per cent had obtained a good new canopy of foliage, and the remainder appeared to be in intermediate stages.

The younger rubber aged ten years or less was not affected to this extent, and appeared to have suffered little if any loss of foliage, though both Oidium and Thrips were frequently observed.

The likelihood of another wintering season being spoiled by rain is small, and one is justified in looking forward to a good wintering and refoliation season next year, though in some foothill areas it would be well to consider the desirability of carrying out sulphur-dusting to control leaf-diseases where local conditions make such diseases of more frequent occurrence.

PAHANG

From reports received from this State, a mild outbreak has been experienced in the older rubber of most districts. Of the

younger rubber the specimens sent in indicate that conditions have been more suitable to the common form of insect and leaf-spot damage, mites, Thrips, spiders and leaf-spot fungi sometimes being found in the same area. Only the late-wintering trees were attacked by mildew following a period of rather dull weather in early April.

Summary

The pronounced dry weather brought on by the N. E. Monsoon caused an intense wintering of rubber trees generally throughout the Peninsula. This drought was unfortunately interrupted in the north by some 12 days of heavy rain, which delayed the wintering by two or three weeks, so that at the beginning of March refoliation was only just beginning instead of being nearly complete as in previous years. Further south, however, weather conditions had remained more favourable and a large percentage of the rubber trees had obtained a good healthy canopy of new foliage before the break in the drought about the 6th or 7th of March. Thus in contrast to previous years the central and southern districts have had a good wintering followed by production of an excellent new foliage comparatively free of disease while the northern districts have had a later wintering than usual and consequently a large proportion of the later refoliating trees were caught by the dull weather of late March and April and suffered attack and considerable leaf-fall by the mildew-fungus.

The number of reports, 129, is considerably less than in previous years, in spite of the usual warning circulated to managers, and publication of last year's Oidium report early in the year. It is noticeable that whereas the numbers of reports from the southern States: Johore, Malacca and Negri Sembilan, show considerable decreases, those from Selangor, Perak and Kedah show progressive increases over the same records for 1937.

As last year the various sulphur-dusting programmes were curtailed or abandoned altogether, as it was considered that the foliage of most of the trees had reached the stage at which it appears to be immune from attack by mildew.

In view of the rapidity with which the disease can spread from infinitely small beginnings, and in view of its usefulness for control of other diseases and pests, the writer again advises estates to provide themselves with a motor or knapsack duster for use in areas of valuable planting material.

The lightning rapidity of this year's outbreak of leaf-mildew points towards the theory that the fungus hibernates in the green buds of the terminal shoots of the rubber trees. There is no gradual spread of infection from a focal point of a field of rubber,

but the disease appears suddenly and simultaneously on any and every tree in that area whose leaves are in the immature stage. Further examination and culture of infected green shoots and leaves in the cold incubator has failed to reveal a resting spore or resting mycelium.

Kuala Lumpur

5th May, 1938

EXPERIMENTS WITH ECONOMIC TAPPING SYSTEMS (1)

BY

C. C. T. SHARP

Part VII

Results of Tapping for the fifth year, June 1937 to May 1938, of Experiment on Seventh Mile Estate

The yield and other records of the fifth and last year of this experiment are presented in Tables XXX to XXXVI.*

When this experiment was commenced the tapping cuts were opened at heights that varied in accordance with the rates of bark consumption. It was originally intended that the cuts of the single-cut systems and the lower cuts of the double-cut systems should reach ground level simultaneously at the end of five years. It was, however, found necessary to modify this plan in order that bark which had been renewing for less than six years should not be tapped, and the opening heights of all the cuts were raised by six inches. This left a reserve of six inches of bark at the base of every tree.

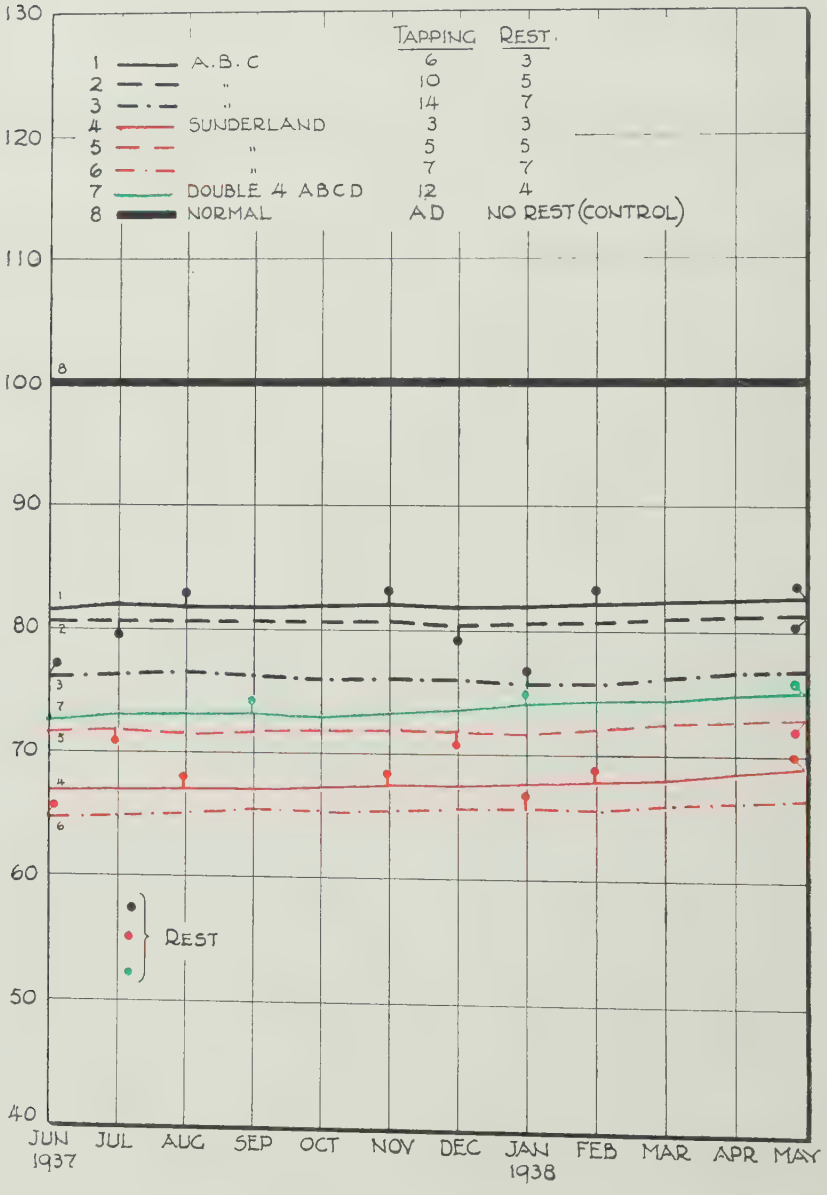
Owing to the variation in thickness and texture of the bark of different trees, it is never possible to maintain an exactly equal rate of bark consumption on all trees tapped on the same system in an experiment of this kind which was designed to compare different tapping systems, as nearly as possible under normal estate conditions.

Owing to this variation in the rate of bark consumption the tapping cuts of a number of trees reached ground level during the last few months before the conclusion of the experiment, and these trees were taken out of tapping. But since this reserve of bark of six inches was constant for all the tapping systems compared, and since the rate of bark consumption was higher in the control plots than in the other plots, the proportion of trees taken out of tapping on account of over-consumption of bark was greatest in the control plots, amounting to nearly nine per cent of the trees, compared with two per cent in the double-four plots and a negligible amount in the other plots (Table XXXVI). This has had the effect of depressing the yield of the control and in consequence of raising in comparison with the control the yields

* The previous papers in this series appear in this *Journal*: **5** (1934) 320-341; **6** (1935) 105-110, **8** (1937) 24-38; **8** (1938) 83-90.

TAPPING EXPERIMENT ON 7th MILE ESTATE

PROGRESS OF TOTAL YIELD AS PERCENTAGE OF CONTROL
5th YEAR



of the other seven tapping systems. This should be taken into consideration when examining the results presented here. The error of the experiment shows a small reduction and differences of nine per cent or over may be regarded as significant.

Plots 8. Alternate-daily Tapping without Resting Periods (Control)

The control plots show a slight decline in yield of 15 lb. per acre which, as explained above, can be accounted for by trees being taken out of tapping during the last few months of this year.

Plots 1, 2 & 3. A.D., A.B.C. with three, five and seven months' rest respectively

Compared with the control, the A.B.C. plots appear to have increased very slightly in yield. The yields of the three A.B.C. systems, though not significantly different from each other, remain in the same order as in previous years, that is to say, system 1 with the shortest periods of rest has continued to give the highest yield and system 3 with the longest periods of rest the lowest yield.

In the second year of tapping the yields of the A.B.C. plots were equal to a little over eighty per cent of the control. No increase in yield can be recorded since that date and the effect of the periods of rest in the A.B.C. plots is clearly not cumulative.

The belief that the A.B.C. tapping system will eventually give yields equal to A.D. is not supported by the results obtained during the five-years' period of this experiment, and evidently does not apply to high-yielding rubber of the type on which this experiment is set up, at least within a period of five years.

Plots 4, 5 & 6. Sunderland System with resting periods of three, five and seven months respectively

The Sunderland system plots are catching up very slowly on the A.B.C. plots, but are still appreciably lower than the latter.

In the A.B.C. and Sunderland systems, the cheapest tapping costs are naturally found in the highest-yielding systems, namely in the A.B.C. plots with six months' tapping and three months' rest (Treatment 1) and in the Sunderland system with five months' tapping and five months' rest. (Treatment 5).

Comparing treatments 1 and 5, the Sunderland system shows a drop in crop of eight per cent and a saving in tapping costs of nine per cent. The A.B.C. system is clearly the better in this experiment.

Plot 7. Double-four

Compared with the control the double-four A.B.C.D. shows a small increase in yield which can probably be accounted for by the smaller number of trees taken out of tapping on account of an over-consumption of bark. Periodical rests during the last two years and eight months have not compensated for the reduction in the number of tappings.

The results given briefly in this paper are for the last year of this experiment. They confirm the results of the previous years and no appreciable change has been found in the relationship of the yields obtained from the different tapping systems.

A complete account of this experiment, recording the results for the whole five years, will be given in a separate publication.

TABLE XXX

June 1937—May 1938

Total Yield per Plot (lb. Dry Rubber) excluding Scrap

Blocks	Plots and Tapping Systems							
	1	2	3	4	5	6	7	8
	A.B.C.	A.B.C.	A.B.C.	Sunderland	Sunderland	Sunderland	Double-four A.B.C.D.	Control A.D.
	6—3	10—5	14—7	3—3	5—5	7—7	12—4	
I ...	2,984.9	2,992.6	2,831.9	2,070.3	2,309.2	2,288.5	4,177.0	2,256.8
II ...	2,916.4	2,678.9	2,548.5	2,034.6	1,909.8	2,156.2	4,228.7	2,115.0
III ...	3,045.4	2,914.5	2,966.4	1,896.9	2,401.4	1,842.6	4,227.3	2,281.6
IV ...	2,999.3	3,405.2	3,095.5	2,281.7	2,466.4	2,127.0	4,617.1	2,669.5
V ...	3,341.7	3,047.3	3,287.4	2,666.9	1,972.8	1,974.4	4,732.5	2,310.7
VI ...	2,871.7	2,550.4	2,226.0	1,891.1	1,965.6	1,955.2	4,023.9	2,378.2
Total ...	18,159.4	17,588.9	16,955.7	12,841.5	13,025.2	12,343.9	26,006.5	14,011.8

Grand Total :—130,932.9 lbs.

TABLE XXXI

Yield in lb. per Acre, for Fifth year of Tapping, of First-Grade Rubber, Scrap and Total Dry Rubber

June 1937—May 1938

	Block Nos.	Plots and Tapping Systems							
		1 A.B.C. 6—3	2 A.B.C. 10—5	3 A.B.C. 14—7	4 Sunderland 3—3	5 Sunderland 5—5	6 Sunderland 7—7	7 Double-four A.B.C D. 12—4	8 Alternate daily (Control)
First-Grade Rubber	I	557.2	558.6	528.6	483.1	538.8	534.0	487.3	631.9
	II	544.4	500.1	475.7	474.7	445.6	503.1	493.3	592.2
	III	568.5	544.0	553.7	442.6	560.3	429.9	493.2	638.8
	IV	559.9	635.6	577.8	532.4	575.5	496.3	538.7	747.5
	V	623.8	568.8	613.6	622.3	460.3	460.7	552.3	647.0
	VI	536.1	476.1	415.5	441.2	458.6	456.2	469.5	665.9
	Mean	565.0	547.2	527.5	499.4	506.5	480.0	505.7	654.0
	Per Cent ...	86.4	83.7	80.7	76.4	77.4	73.4	77.3	100.0
Scrap	Mean	44.0	43.9	40.1	52.2	52.2	48.5	54.9	55.0
	Per Cent of First-Grade Rubber	7.8	8.0	7.6	10.5	10.3	10.1	10.9	8.4
Total Dry Rubber	Mean	609.0	591.1	567.6	551.6	558.7	528.5	560.6	709.0
	Per Cent ...	85.9	83.4	80.1	77.8	78.8	74.5	79.1	100.0

General Mean 535.7 lbs. of First-Grade Rubber per acre

TABLE XXXII

Mean Yield in lb. per Acre per month, of First-grade Rubber

June 1937—May 1938

	Plots and Tapping Systems																							
	1 A.B.C. 6—3 Yield			2 A.B.C. 10—5 Yield			3 A.B.C. 14—7 Yield			4 Sunderland 3—3 Yield			5 Sunderland 5—5 Yield			6 Sunderland 7—7 Yield			7 Double-four A.B.C.D. 12—4 Yield			8 Alternate-daily (Control) Yield		
	lb.	per cent.	Total per cent.	lb.	per cent.	Total per cent.	lb.	per cent.	Total per cent.	lb.	per cent.	Total per cent.	lb.	per cent.	Total per cent.	lb.	per cent.	Total per cent.	lb.	per cent.	Total per cent.	lb.	per cent.	Total per cent.
June 1937	44.8	77.8	81.6	47.1	81.8	80.6	42.0	72.9	76.0	36.1	62.7	66.7	44.9	78.0	71.6	37.9	65.8	64.5	42.0	72.9	72.9	57.6	100.0	100.0
July „	49.5	87.5	81.8	44.7	79.0	80.6	48.1	85.0	76.2	42.6	75.3	66.8	43.9	77.6	71.7	38.6	68.2	64.6	45.8	80.9	73.3	56.6	100.0	100.0
August „	50.0	77.0	81.7	51.9	80.0	80.6	53.3	82.1	76.4	45.6	70.3	66.9	38.6	59.5	71.4	51.0	78.6	64.9	48.7	75.0	73.4	64.9	100.0	100.0
September „	51.7	85.7	81.7	52.5	87.1	80.7	51.2	84.9	76.2	38.5	63.5	66.9	48.3	80.1	71.6	48.6	80.6	65.3	45.6	75.6	73.5	60.3	100.0	100.0
October „	62.1	83.4	81.8	57.3	77.1	80.6	52.0	70.0	76.0	54.6	73.5	67.0	55.5	74.7	71.7	47.7	64.2	65.2	47.1	63.4	73.0	74.3	100.0	100.0
November „	54.1	91.9	82.0	45.9	77.9	80.6	44.5	75.6	76.0	43.8	74.4	67.2	43.2	73.3	71.7	40.5	68.8	65.3	49.8	84.6	73.4	58.9	100.0	100.0
December „	47.2	74.8	81.8	45.7	72.4	80.4	41.6	65.9	75.8	39.9	63.2	67.1	42.2	66.9	71.6	43.1	68.3	65.4	49.1	77.8	73.6	63.1	100.0	100.0
January 1938	45.3	83.6	81.9	46.6	86.0	80.5	35.9	66.2	75.6	43.8	80.8	67.4	36.5	67.3	71.5	36.5	67.3	65.5	38.6	71.2	74.2	54.2	100.0	100.0
February „	44.2	95.7	82.1	44.7	96.8	80.7	43.3	93.7	75.6	37.5	81.2	67.6	45.2	97.8	71.9	29.2	63.2	65.4	36.2	78.4	74.3	46.2	100.0	100.0
March „	38.9	96.5	82.3	38.4	95.3	80.9	42.9	106.5	76.3	30.5	75.7	67.7	37.2	92.3	72.2	40.3	100.0	65.8	34.9	86.6	74.5	40.3	100.0	100.0
April „	43.1	102.4	82.5	38.3	91.0	81.1	40.0	95.0	75.6	47.6	113.1	68.3	38.4	91.2	72.5	35.7	84.8	66.1	36.4	86.5	74.9	42.1	100.0	100.0
May „	34.2	96.1	82.7	34.0	95.1	81.2	32.0	89.9	76.7	38.9	109.3	68.8	32.6	91.6	72.7	31.0	87.1	66.3	31.5	88.5	75.2	35.6	100.0	100.0

NOTE:—*The thick horizontal lines show the points at which tapped and rested sections were changed over*

TABLE XXXIII

Analysis of Variance. First-Grade Rubber

	Degrees of Freedom	Sums of Squares	Mean square
Treatments ...	7	127,303.0	18,189.0
Blocks ...	5	52,110.5	10,422.1
Error ...	35	60,679.5	1,733.7

TABLE XXXIV

Yield per Tapper and Comparative Cost of Tapping

June 1937—May 1938

Tapping System	Yield per Tapper per Tapping			Comparative Cost per lb.		Comparative Yield per Acre	
	First-Grade Rubber lb.	Scrap Rubber lb.	Total Dry Rubber lb.	First-Grade Rubber per cent	Total Dry Rubber per cent	First-Grade Rubber per cent	Total Dry Rubber per cent
1	17.5	1.4	18.9	77.1	75.8	86.4	85.9
2	17.0	1.4	18.4	79.4	77.9	83.7	83.4
3	16.3	1.2	17.5	82.8	82.0	80.7	80.1
4	18.6	2.0	20.6	72.6	70.1	76.4	77.8
5	18.9	2.0	20.9	71.4	69.1	77.4	78.8
6	17.8	1.8	19.6	75.8	73.4	73.4	74.5
7	16.7	1.8	18.5	80.9	77.9	77.3	79.1
8	13.5	1.1	14.6	100.0	100.0	100.0	100.0

TABLE XXXV

Mean Dry-Rubber-Content, Per Cent

June 1937—May 1938

Month	Tapping Systems							
	1	2	3	4	5	6	7	8
June 1937 ...	42.8	39.2	38.6	48.2	39.5	39.7	44.0	39.5
July „ ...	41.5	39.5	43.2	41.9	39.9	48.8	42.9	40.2
August „ ...	42.0	44.4	41.9	41.4	48.4	42.4	43.6	41.9
September „ ...	43.7	41.4	39.5	47.2	41.9	40.7	42.7	40.0
October „ ...	39.8	38.9	38.5	40.8	39.2	38.7	43.8	39.4
November „ ...	38.9	38.7	37.9	39.2	37.9	38.3	40.8	38.6
December „ ...	42.6	39.2	38.7	48.4	38.1	38.1	41.1	38.9
January 1938 ...	41.7	44.1	40.1	42.8	49.8	39.4	42.3	40.5
February „ ...	41.5	42.2	43.8	41.7	43.4	50.6	44.8	41.0
March „ ...	42.5	38.8	39.8	46.9	39.7	41.7	42.0	38.9
April „ ...	39.2	37.4	37.3	41.1	38.3	39.0	40.4	37.1
May „ ...	38.0	37.7	37.2	39.2	38.4	38.6	40.1	38.1

NOTE.—The thick horizontal lines show the points at which the tapped and rested sections were changed over

TABLE XXXVI

The percentage of Trees taken out of Tapping before the end of the Experiment owing to over-consumption of Bark

Tapping System	Percentage of Trees out of Tapping	Tapping System	Percentage of Trees out of Tapping
1	1.3	5	0.2
2	0.6	6	0.1
3	0.8	7	2.0
4	0.5	8	8.8

Kuala Lumpur
27th October, 1938

PREVENTION OF MOULD GROWTH ON SHEET RUBBER DURING STORAGE

BY

J. D. Hastings & J. H. Piddlesden

The recent arrangement which permits estates to build up larger stocks of rubber during the present period of low export releases, has brought the problem of storage very much to the fore. In addition to the use of disinfectants much can be done by care in the preparation and storage to ensure that the rubber will keep satisfactorily. The following factors favour the growth of mould (1):—

(1) Residual hygroscopic serum bodies in the rubber.

(2) The packing of imperfectly dried rubber.

(3) Insufficient smoke substances in the dry sheet.

(4) Centres of infection.

(5) Damp storage conditions.

(1) Residual Serum Substances

The first factor can be reduced to a minimum by ensuring that a copious supply of wash water is available on the sheeting battery, and that serum and water from the rolls do not fall into any washing or soaking tank used at the end of the machine. In this way the serum substances are removed as completely as possible.

(2) Packing Conditions

The rubber must be thoroughly dry when it is packed. As far as possible, therefore, it should not be removed from the smoke-house during wet weather. Moreover, since the relative humidity of the atmosphere in this country is very high from early evening until the sun is well up on the following morning, the sheet should not be removed from the smoke-house before 9 a.m. A high atmospheric humidity favours the absorption of water by the rubber. Any rubber taken out of the smoke-house in the morning should therefore be packed before evening in cases which have been dried thoroughly by the sun. If it is not possible to finish the packing, the balance of the rubber should be kept in the smoke-house over-night.

(3) Effect of Smoke

It has been found in practice that some of the smoke-bodies absorbed by the rubber have a strong preservative action. The effect seems to be correlated roughly with the colour of the sheet, and in general it may be said that mould resistance will increase as the colour of the sheet deepens. It is therefore advisable to adjust the smoke-house to give as dark a sheet as possible. The quantity of smoke from the furnace can in many cases be increased by reducing the supply of air through the fire. Because of restricted outputs many estates now have vacant smoke-house space, and can thus produce a darker sheet by increasing the thickness slightly or reducing the smoke-house temperature a little, and allowing one day more for drying. Reference to a new type of furnace, and a suggestion for modifying some existing types to produce more smoke, will be found in a paper dealing with smoke-house experiments in the present issue of this *Journal*.

(4) Centres of Infection

It is well known that mould grows from air-borne spores. These are always present in the air and there is no practical way of keeping sheet rubber absolutely free from infection, though the risk will be much reduced if the air is kept as free from mould spores as possible. For this reason damp or mouldy off-quality rubber should not be allowed to lie about in the packing shed, but should if possible be stored in a separate building, while contact between the sheet and such material should be avoided. For the same reason it is not advisable to dry scrap in the smoke-house. A separate small chamber to dry this material can be built for a few dollars. It is not uncommon to find small specks of mould growing in the grain of the smoke-house *beroties*. These should therefore be inspected at regular intervals, and if mould is detected, the *beroties* should be scrubbed with a solution of a disinfectant such as formalin, para-nitrophenol or any proprietary preparation of the carbolic type.

(5) Storage Conditions

Storage under the driest possible conditions is a factor of primary importance in the preservation of smoked sheet. This is well illustrated by our laboratory method for testing susceptibility to mould by suspending the sample in a saturated atmosphere. In this test it is not uncommon to find mould developing in three or four days, while pieces of the same rubber exposed to the open air of the laboratory, which is well ventilated, are still free from mould after two or three months. The cases

of packed rubber should therefore be stored in a dry, well-ventilated place, and should be stacked with planks between them, so that there is an air space of a few inches all round each case. The storage shed should be operated on the same lines as a crepe-drying shed, *i.e.* opened up during the day to ensure good ventilation, and closed at night to exclude the damp air. In extreme cases where the storage shed is in a very damp situation it is worth while considering the possibility of heating the shed at night, by means of a small charcoal fire or a kerosene heating lamp. Such a step should be taken only after consultation with an insurance company and the arrangement of adequate cover in case of fire. The temperature should be maintained at 90°F. to 95°F.

No matter what precautions are taken, there can be no absolute guarantee that the rubber will be kept free from mould. The only positive method of ensuring that no mould is present at the time of despatch is to inspect the rubber just before it is shipped. This operation is difficult if the sheet has been pressed into cases, but the difficulty may be overcome by storing the sheet loose in such a way that it is well protected, and that the risk of sheets massing together is reduced to a minimum. To accomplish this it is suggested that lots of 100 to 150 sheets be arranged in a flat pile which is wrapped first in wrapping sheets, then in a layer of gunny sacking which has previously been soaked in para-nitrophenol solution and dried thoroughly. The bundles so prepared can then be stored on edge on shelves in a well-ventilated place. When the time comes for shipment, it should be relatively easy to open up these bundles and remove for re-conditioning any defective sheets, before packing is carried out in the normal way. Mouldy sheet can be reconditioned by scrubbing it in para-nitrophenol solution and drying it in the smoke-house. This method is troublesome but will guarantee that the rubber is free from mould when it leaves the estate.

The Use of Chemical Preservatives

Para-nitrophenol is recommended as the most suitable chemical preservative for incorporation into the rubber (2), (3). The substance is sparingly soluble in water and is usually prepared in the form of a one-per-cent stock solution by dissolving 1-lb. of the solid in 10 gallons of water. The stock solution should be mixed some time before it is required for use. It can be applied to the rubber either by mixing it with the latex before coagulation, or by soaking the freshly-machined sheet in a bath of the solution. In the first method the stock solution is added at the rate of one gallon to sixty gallons of diluted latex, just

before addition of the coagulant. This method gives very good protection against mould but requires 1-lb. of para-nitrophenol per 900 lb. of rubber. For the soaking treatment 5 gallons of one-per-cent stock solution are diluted with 50 gallons of water and this mixture is sufficient to soak 1,000 lb. of sheet, *i.e.* 1-lb. of para-nitrophenol is required for every 2,000 lb. of rubber. Soaking gives effective protection if it is carried out thoroughly, and care is taken to see that both surfaces of each sheet come freely into contact with the solution. In practice this is not easy to do when large numbers of sheets are being handled, since they tend to mass together, and labour is required to separate them at intervals and to see that they are completely submerged. In the system employed on one estate, two spare coagulating tanks containing the diluted para-nitrophenol solution are used. A pile of sheets which has been cut and partially drained is placed in one end of the first tank. Two labourers then separate the sheets one by one, pass them through the solution in the centre of the tank and re-pile them, still in the solution, at the far end. The pile is then left soaking while the second tank is dealt with. The rubber from the first tank is then removed for hanging and the process is repeated until the crop is finished. This method employs two labourers for several hours but is said to be very efficient and cheaper than adding the preservative to the latex.

Table I gives a few examples of mould tests, carried out on samples submitted by estates, and illustrates the unsatisfactory results obtained by soaking if it is not efficiently carried out.

TABLE I

Estate	Days required for Control to show Mould	Treatment	Days required for Treated Sample to show Mould
A	5 days	Coagulum soaked for few mins. before and after marker	10 days
B	3 days	P.N.P. added to latex	15 days
C	3 days	Sheet soaked in P.N.P.	9 days
D	5 days	P.N.P. added to latex	> 13 days
		Sheet soaked in P.N.P. for 30 mins.	4 days
		Sheet soaked in P.N.P. for 15 mins.	4 days
		Sheet dipped in P.N.P.	4 days

TABLE II

Sample	Treatment	Test	Days required for first sign of Mould	Days required for general Mould	Days required for heavy Mould
1	Air-dried control	a	3	4	5
		b	3	4	5
2	Dipped in one-per-cent P.N.P. solution diluted with 10 times its vol. of water	a	4	6	14
		b	5	6	13
3	Soaked for 15 mins. in above solution	a	22	—	—
		b	23	—	—
4	Sprayed with 0.25 per cent P.N.P. solution ...	a	5	8	16
		b	5	6	16
5	Dripped for 3 hours then treated as 2	a	4	5	6
		b	5	6	13
6	Dripped for 3 hours then treated as 3	a	7	11	—
		b	7	12	—
7	Dripped for 3 hours then sprayed as 4	a	7	10	27
		b	7	10	27
8	P.N.P. added to Latex at standard rate	a	26	—	—
		b	26	—	—
9	Estate smoked sheet without P.N.P.	a	5	7	11
		b	5	7	11

Freshly-machined sheet soaked, dipped or sprayed with para-nitrophenol solution has been compared in the laboratory with dripped sheet similarly treated, and with sheet made from latex containing this solution. Spraying was tried, as it was thought that this might prove a convenient method of treating the sheet while it was hanging on the smoke-house truck. This would avoid the risk, which arises when piles of sheets are soaked, that some of the rubber might not meet the solution. The experiment was carried out in duplicate and the results appear in Table II.

It will be seen that in the laboratory trial, where each sheet was soaked separately, soaking proved almost as effective as addition of para-nitrophenol to the latex. Spraying was not satisfactory, nor did it prove desirable to drip the sheet before the para-nitrophenol treatment was carried out. It is probable that after the fairly prolonged dripping period a dry skin was formed on the rubber, through which the para-nitrophenol solution could not penetrate.

Defects in Sheet treated with Para-nitrophenol

From the inquiries which have reached the Institute recently it is evident that many estates are using para-nitrophenol as a mould-preventive, and several reports of bubbly and blistered sheet have been made which could be traced to its use. In one instance it was found that drying at a high temperature in absence of para-nitrophenol occasionally caused slight blistering. When para-nitrophenol was added to the latex, the whole crop showed bubbles or small blisters, which suggested that para-nitrophenol lowers the temperature at which blistering occurs.

To obtain further information on this point some experiments at various temperatures were made on the drying of normal sheet rubber prepared from latex to which para-nitrophenol had been added in the recommended quantities before coagulation. Since many estates are obliged to use sodium sulphite in their latex to avoid pre-coagulation, similar experiments were carried out with latex to which normal amounts of sodium sulphite had been added some time before dilution and coagulation. The results are tabulated in Table III, and confirm that the addition of P.N.P. to the latex has made the rubber more sensitive to heat. While temperatures of approximately 140°F. are not to be recommended and are not commonly used on estates in the early stages of drying, sheet can often be dried at this temperature without blistering. When para-nitrophenol is used, this temperature is almost certain to produce bubbles and blisters. It appears also that the addition of sodium sulphite makes the rubber more sensitive and therefore it is not surprising to find that when

sulphite and para-nitrophenol are used together the tendency for blisters and bubbles to appear is greater than when either is used alone. In order to ascertain if this heat-sensitivity is confined to the early stages of drying, sheet containing para-nitrophenol was kept in hot air, at 120°F. for 24 hours, then at 140°F. until dry. An occasional small bubble was noticed, but the sheet was good in comparison with the controls which were dried at 140°F. throughout and were very badly blistered. A similar but less pronounced heat-sensitivity has been observed with sheet soaked in para-nitrophenol solution.

TABLE III

Influence of Treatment and Preparation on Condition of Sheet

Sample No.	Treatment before Coagulation	Drying Conditions	Condition of Sheet
L 74/1		Hot-air at 120°F.	Good
L 74/1/1	P.N.P. added to latex	„ „ „	Good
L 74/1/2	Sodium Sulphite added to latex	„ „ „	Good
L 74/1/3	P.N.P. and Sodium Sulphite added to latex	„ „ „	Few Bubbles
L 74/2	—	Smoke at 130°F.	Good
L 74/2/1	P.N.P. added to latex	„ „ „	Few Bubbles
L 74/2/2	Sodium Sulphite added to latex	„ „ „	Few Bubbles
L 74/2/3	P.N.P. and Sodium Sulphite added to latex	„ „ „	Bubbles
L 74/3	—	Hot-air at 140°F.	Good
L 74/3/1	P.N.P. added to latex	„ „ „	Badly Blistered and Bubbly
L 74/3/2	Sodium Sulphite added to latex	„ „ „	Bubbles
L 74/3/3	P.N.P. and Sodium Sulphite added to latex	„ „ „	Badly Blistered and Bubbly

From these experiments it is concluded that when para-nitrophenol is used in the latex, and to a less extent when the sheet is soaked in it, careful attention must be paid to smoke-house temperatures, particularly in the early stages of drying. Reduction of the temperature results in slower drying, but this may be an advantage, as it tends to produce a darker sheet more resistant to mould attack.

Literature cited

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Kuala Lumpur,

21st September, 1938

EXPERIMENTS WITH A NEW TYPE OF SMOKE-HOUSE

BY

J. H. Piddlesden

Introduction

Although the "Subur" type smoke-house (1) which has been recommended by the Institute for the last two or three years marked a distinct advance on the older types of smoke-house, it has been felt for some time both by ourselves and various estate engineers and managers that it could be improved upon. Experiments have been in progress on the Institute's Experiment Station for a year to this end and at the same time a number of smoke-houses of new types have been built independently by estates. It is intended in this paper to give a brief description of some of these estate buildings together with an account of the experiments made by the Institute and details of the type of smoke-house which has been finally evolved as a result of them.

One of the main objections to the Subur type smoke-house is the necessity of utilising turn-tables and moving the rubber from one chamber to the next each day. A straight rail-track running through a building of the tunnel type is the obvious solution, but this involves forfeiting the separate independent control of temperature which is one of the main features of the earlier type with its separate compartment for each day's sheet. This has not proved as serious as was at first feared, since experience has shewn that although by such control the drying can be carried out more efficiently and quickly, speed is not the only factor in curing sheet rubber. Although sheet can be dried in three days in a Subur smoke-house, four days is considered necessary for adequate smoking. The close temperature control made available by this type of buildings is not therefore vitally necessary and is not in fact generally used to the full.

Another objection to the Subur type is that of cost. Elimination of the turn-tables and interior partition walls would save some of this outlay, as would a reduction in the number of doors. The brick building remains expensive in spite of such modifications. Resistance to fire was the main reason for which the brick and steel construction was widely adopted. Experience has shewn that this risk arises more from lack of care in firing and from the accumulation of inflammable gases than from the use of inflammable building materials. Smoke-houses built of bamboo and paper have been used successfully for over two years

at the Institute's Experiment Station, and buildings constructed of similar materials are still in use after a number of years on several large estates in Java. On the other hand, a number of brick smoke-houses have been burnt in this country in the last few years. It is true that in some cases it has been possible to salvage much of the material and rebuild the smoke-house, whereas a wooden building would have been completely destroyed, but the cost of such reconstruction may easily be as great as that of building an entirely new smoke-house of cheaper materials. A well-constructed cavity-wall with wooden planks on the outside and a suitable insulating board forming the inside surface gives quite satisfactory heat insulation and is much cheaper than brick. It is therefore suggested that this type of construction is suitable for tunnel-type smoke-houses.

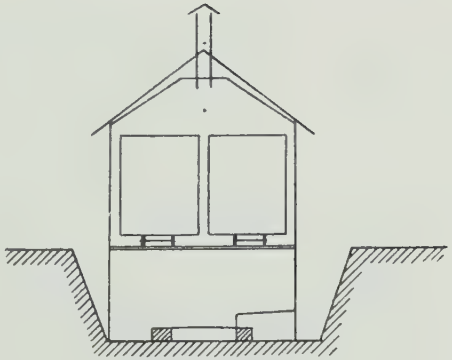
Some Tunnel-type Smoke-houses in Use on Estates

Type 1. (*See Figure 1*)

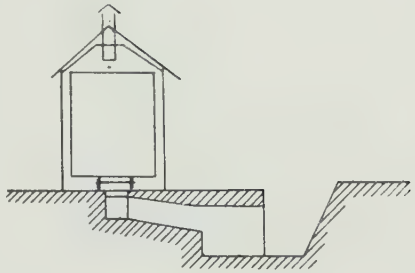
Probably the first design utilising this straight-through principle was the one using a separate building for each day's crop. Two, three, or four buildings may be used spanning a single or double rail-track. The furnaces are usually half-way along the side of each building and may be inside or outside the side walls. In all cases the furnace is well below ground level. The ground may be excavated down to furnace level right round the outside walls; it may be excavated over the whole area of the inside of the chamber only, using the side walls as earth retaining walls; or space for the flues only may be dug out. One well-known design which employs steam heating and dries the rubber in two days follows this system of a separate building for each day's drying with a straight-through rail system.

This system of separate buildings is excellent for large estates manufacturing over two tons of rubber per day, for here several buildings and furnaces would be needed in any case and the method of operation is simpler than that required for a number of separate smoke-houses, each drying a portion of the crop completely. For a small estate with a yield of 2,000 lb. or less per day, where only two trolleys per day are needed it is obviously uneconomic to erect three or four separate buildings with a corresponding number of furnaces, doors, etc. For small units attempts have been made to work with only two buildings, leaving the rubber in each one for two days. This has proved successful, but does not appear to offer any advantage over the Subur type either in first cost or in running cost. Outline sketches of this type appear in Figure 1.

TYPE 1



END ELEVATION



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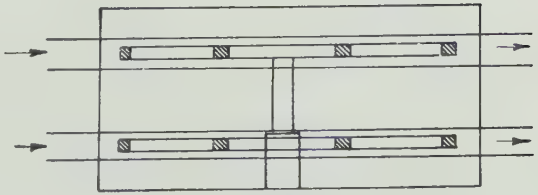
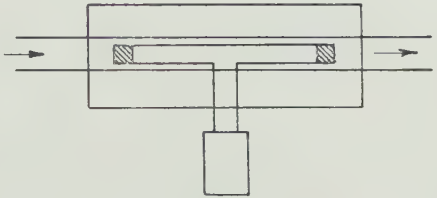


PLAN

LARGE UNIT

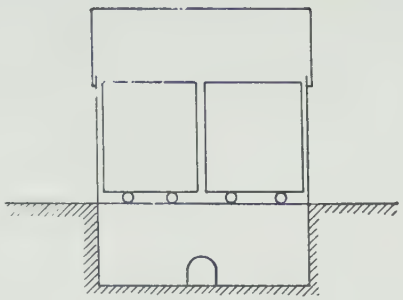


PLAN

SMALL UNIT

FIG. 1

TYPE 2



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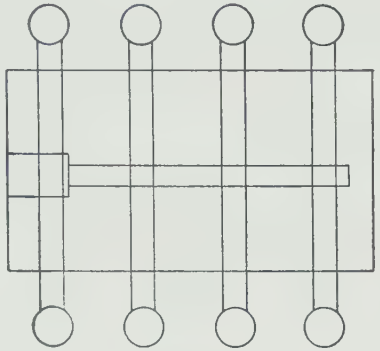
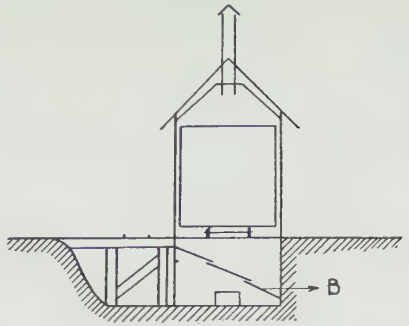


PLAN

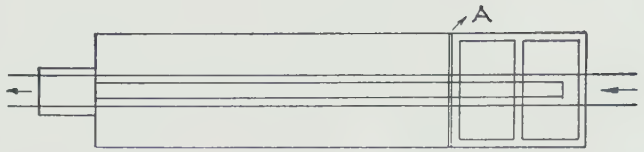
FIG. 2

TYPE 3



END ELEVATION

A. INNER DOORS
B. DRAIN BAFFLES.



PLAN

BERADIN TYPE

FIG. 3

Type 2. (*See Figure 2*)

Another type of smoke-house which has appeared on one or two estates and is said to work satisfactorily is a straight-through type in which the flue, in an underground chamber, runs at right-angles to the rails of which four sets are generally used. It resembles the Subur type but has doors at the front and back, and has a lower flue chamber excavated to a depth of about six feet over the whole area of the house with the flue built up on the floor of this chamber. It has the advantage that it can be extended almost indefinitely. The large deep flue chamber is necessary to obtain a uniform distribution of temperature. In a large unit it may be possible to get increasing temperatures as the rubber passes through the house, but for small buildings using only one flue this cannot be done and temperature variations through the house must in fact be kept to a minimum for successful working.

Type 3. (*See Figure 3*)

In this general type the underground flue runs parallel to the single or double rail-track, and the furnace is at one end under the rails. Several variants of this type have been erected, differing in details of design and in the amount of excavation carried out. The most interesting example is perhaps that built on Beradin Estate and described in the *Straits Times* for December 31st, 1937. This building incorporates several new and useful ideas. The trucks were made wide in comparison with their length, so that eight trucks can be accommodated on a single track inside the building without the latter having to be made excessively long. The building is divided into two compartments at a point three-quarters of its length from the furnace end, by means of a brick partition across the lower flue chamber, and doors across the upper smoking chamber. The wet sheet is thus isolated for the first 24 hours from the remainder of the rubber in the smoke-house. In this first compartment there is a sloping baffle running across the house below the rails to collect any drippings. These are drained off through a gully and outlet pipe. The trucks are 10 feet wide, 6 feet long, and 9 feet 6 inches high and run on a 3 feet 6 inches gauge rail-track through the tunnel, which is approximately 52 feet long and 12 feet wide. The floor of the lower chamber is 6 feet below rail level and carries a horizontal rectangular flue 18 inches wide by 2 feet deep.

All of the buildings described are working satisfactorily and some of them are simpler to control and operate than the Subur type. The cost was usually of the same order as that of the Subur, except where cheaper materials of construction were used, or

where the house was designed for a large capacity, in which case the capital cost per 1,000 lb. of rubber could be reduced. They are all characterised by one disadvantage in that they required a considerable amount of excavation, which renders it extremely expensive, if not impossible, to build them on sites where the water-table is high.

Experiments at R.R.I. Experiment Station

An attempt was made to design a tunnel smoke-house which would not involve costly deep excavation and which would for this reason be suitable even for wet sites. It had long been realised that the hot gases escaping from the smoke-house when the rubber was almost completely dry were far from saturated, and it therefore seemed probable that economies could be effected by passing these gases through the wet rubber, and it was resolved to incorporate this idea in the design. A simple tunnel was therefore built large enough to hold four trucks each carrying about 600 lb. of rubber. Cavity-walls with wood on the outside and an asbestos-cement board as the lining were used. The roof was of corrugated iron with a flat inner ceiling, and thin sheet baffles were loosely attached to one end of each truck. The furnace consisted of an oil drum, insulated with boiler composition sunk just far enough into the ground to enable the flue pipe to pass under the rails. The chimney was arranged to draw off from below the centre of the truck at the cooler end. The resulting arrangement is shewn diagrammatically in Figure 4.

Many attempts were made to make this system work by alterations to the chimney and furnace, application of heat at the base of the chimney to induce draught etc., but the results were all disappointing. It proved impossible to get sufficient draught through the smoke-house and the end remote from the chimney remained cold. The baffles were removed from between the trucks in an attempt to get a straight horizontal flow of hot gas, also without success. One of the reasons for trying to obtain down-draught through the truck remote from the fire was that if this could be achieved, the ceiling would be warmer than the floor at this end, so that any condensation which occurred would tend to take place first on the floor. It was thought that this would help to overcome the difficulty which has been experienced in some smoke-houses where moisture has condensed on the ceiling, dripped back and stained the rubber.

The next step was to blank-off the chimney and to instal a ventilator over the end truck. This gave slightly more promising

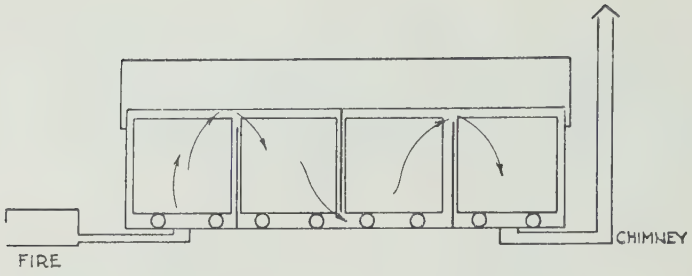


FIG. 4

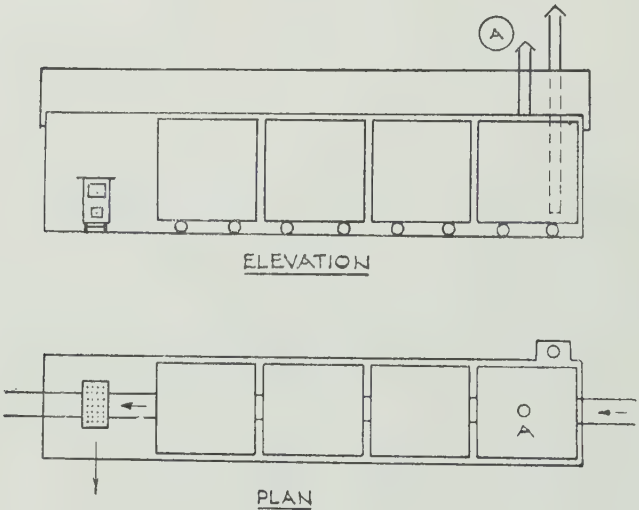


FIG. 5

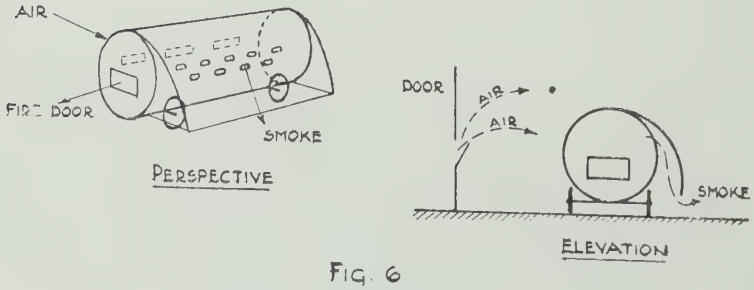


FIG. 6

results, and by this means is was possible to get a few of the sheets on the top racks dry in four days. The heat inside the smoke-house was still insufficient however, and it was therefore decided to try a fire inside the building. One truck was accordingly omitted and its place was taken by a firebox constructed from an old oil drum mounted horizontally on wheels. This appeared to be more successful, but still most of the heat and smoke appeared to be close to the ceiling.

At this stage the building was re-modelled. The length was increased by eight feet so that it would contain the firebox and four trucks. A small bay was built on to the side to contain a chimney in a renewed attempt to draw off the gases from near the floor, in order to obtain a more uniform vertical distribution of heat in the building. At the same time a more permanent firebox was installed consisting of a vertical rectangular box on wheels with firebars at the bottom, a fire door in the side and holes in the top for the smoke to escape. Air was admitted through ventilators in the doors of the tunnel at the furnace end. There was also a small side door in the tunnel through which the firebox could be withdrawn for stoking. The general arrangement is shewn in Figure 5. This system worked at first only with ventilator A (figure 5) opened, and under these conditions it was impossible to get the sheet on the lower racks dry. A number of tests were carried out and by adjustment to the air inlets, the use of a baffle over the smoke outlets on the firebox, and a further baffle across the tunnel between the fire and the first truck reaching from the ceiling to within one foot of the floor it was found possible to dispense with ventilator A. There still remained a marked difference in rate of drying and final colour of the rubber between that from the top and bottom of each truck.

In order to force the smoke nearer the floor the firebox was again changed for a horizontal drum. This was constructed with air inlets on the side nearer the doors and smoke outlets as low down as possible on the side near the rubber. A cowl was fitted over the smoke outlets to force the smoke down. Cowls were also fitted over the air inlets in the doors to send the incoming air up over the fire drum, as shewn in Figure 6.

A large number of trials were carried out with this arrangement on varying types of sheet and with various alterations to the holes in the fire drum, height of chimney etc. It was found that sheet could be dried successfully in four days and that the fuel economy was good. It was still not possible to get a uniform colour on the sheet. That from the top racks was much darker than that dried on the lower tiers of the trucks. Another difficulty was that the proximity of the fire-box to the rubber rendered the temperature control very sensitive. Very careful control of the

firing was necessary to maintain a steady temperature. The wood used had to be cut very small and added at frequent intervals. If larger pieces were used the temperature rose and fell between wide limits. We were therefore very reluctantly forced to the conclusion that a tunnel smoke-house of this type with the furnace above ground level could not be recommended with full confidence for estate use. It has since come to our notice that one estate is operating a smoke-house on these lines (2), but in this case six days are allowed for drying and it is stated that "the bottom racks are used only in emergency."

Experiments with Underground Flues

Attention was now turned to designs in which the smoke and hot gases were led in by flues under the floor level. It was considered essential to reduce excavation to a minimum and the flues were therefore constructed as open troughs covered in with precast concrete slabs. The floor of the firebox and flue was made as near to the surface of the ground as was possible. The firebox was placed at the side, with an inlet flue 18 inches wide by 18 inches deep leading in to the smoke-house between the third and fourth trucks. This joined a one-foot-wide flue running between the rails, with a one-foot-square outlet below the centre of each truck. The flue was 18 inches deep at its lowest point and 12 inches deep at the ends. The trucks were fitted with an arched metal baffle fitted low down and running the full length of each truck, spanning the centre 2 feet 6 inches of their width. These served not only to spread the smoke but to throw off to the side, clear of the rails and flue, any water dripped from the sheet. The floor on each side of the rails was sloped towards the side walls, where there was a shallow drain to take off any water. The features briefly described here were retained in the house in its final form, and further details appear with the plans in the appendix to this article. It was desired at this stage to avoid the expense of changing the flat ceiling for one which would follow the line of the roof and funnel-shaped ventilators were therefore used, one being installed over the centre of each truck. (See Figure 7). Control was readily effected by suspending a circular plate slightly larger in diameter than the outlet pipe in the funnel portion. This device is described, as it gives a very cheap satisfactory controllable ventilator for use with flat ceilings.

Furnace

The furnace consisted of an oil drum packed round with sand Provision was made to admit air between the top of the drum and and enclosed in a brick box with a reinforced concrete top.

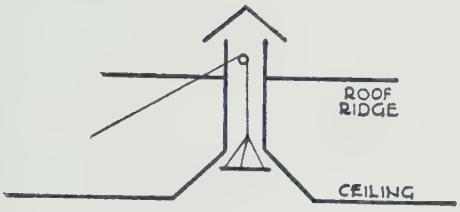
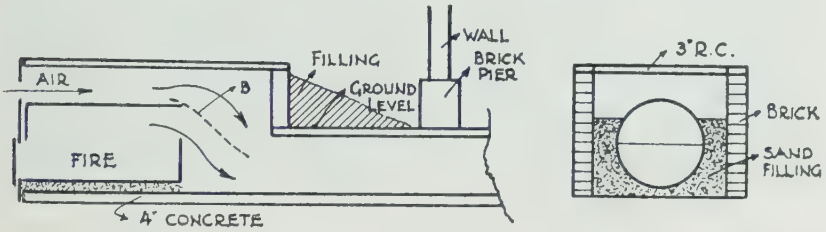


FIG. 7.

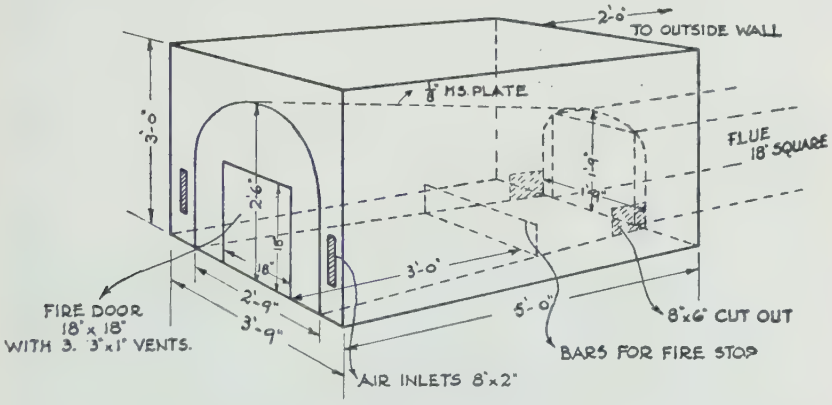


END ELEVATION SECTION

FRONT ELEVATION SECTION

FIRE BOX

FIG. 8.



INSIDE DIMENSIONS SHEWN
SIDE WALLS 4½" BRICK
TOP 3" REINFORCED CONCRETE.

PERSPECTIVE SKETCH OF METAL ARCH FURNACE.

FIG. 9.

the concrete top, with the double object of preheating the air and cooling the top of the firebox. The assembly was completed by a steel face-plate which was bolted on and contained the fire door. Since the walls were only of single brick, and there were no arches or firebrick used, this gave a very cheap furnace. The arrangement can be seen in Figure 8. At its lowest point the furnace and main flue was only 18 inches below ground level.

When this system was first put into operation it was found that the air intake over the fire did not work satisfactorily and that instead of drawing in air, the fire tended to burn back over the top of the drum. The installation of a baffle (B. Figure 8) improved matters in this respect, but the draught through this air aperture remained rather uncertain. Also in the early stages the fire gave volumes of smoke but barely sufficient heat. When it had been in continuous operation for a week and become thoroughly dried out, the furnace structure became very hot. The house then worked very successfully from the drying point of view, the desired temperatures were easily attained and could be kept remarkably steady with very little supervision of the labourer responsible for the stoking. The fire however produced practically no smoke. All attempts to overcome this objection, by careful control of the amount of air admitted to the fire, alterations in the fuel mixture, and in thickness of the sheet used for tests gave only small improvements in the colour of the finished sheet. When the tests were interrupted for several days and the house was restarted from cold it was found that volumes of smoke were again produced for the first day or two. This indicated that the absence of smoke was due to the high temperature and heat-retaining capacity of the furnace structure, which seemed to get sufficiently hot to burn up the smoke from any freshly-inserted wood. A consideration of other smoke-houses which are in regular use confirmed this view. Buildings having massive brick or firebrick furnace structures, such as the Subur type, almost invariably give pale sheet, whereas those having sheet steel furnaces not surrounded by earth, brick, or lagging, give much more smoke.

The drum and sand packing were therefore removed from the furnace shell and replaced by a tapered arch of thin sheet metal which rested freely on the furnace floor and was well clear of the walls and top. Air inlets were cut at each side of the face-plate low down between the arch and the wall. The metal arch was long enough to reach right back to the furnace end of the main flue. It contained two or three bars to act as fire stops at about two feet from the flue and had an air-hole cut out low down on each side at the back, to enable the air which had travelled along outside the arch to enter the flue. A perspective

PLATE I. Side view of Building showing Furnace.

PLATE II. Reverse side showing Return Rail Line.

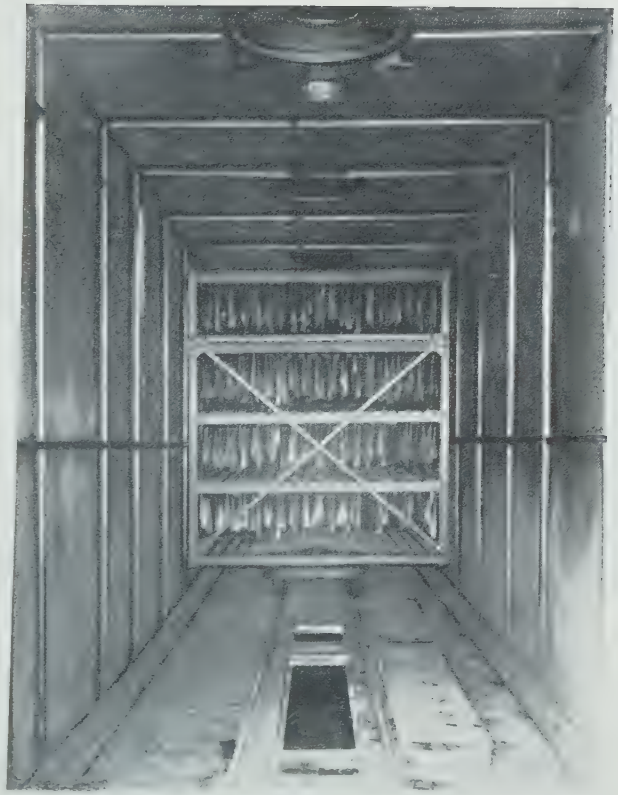


PLATE III

PLATE IV

Views of Interior of Tunnel.

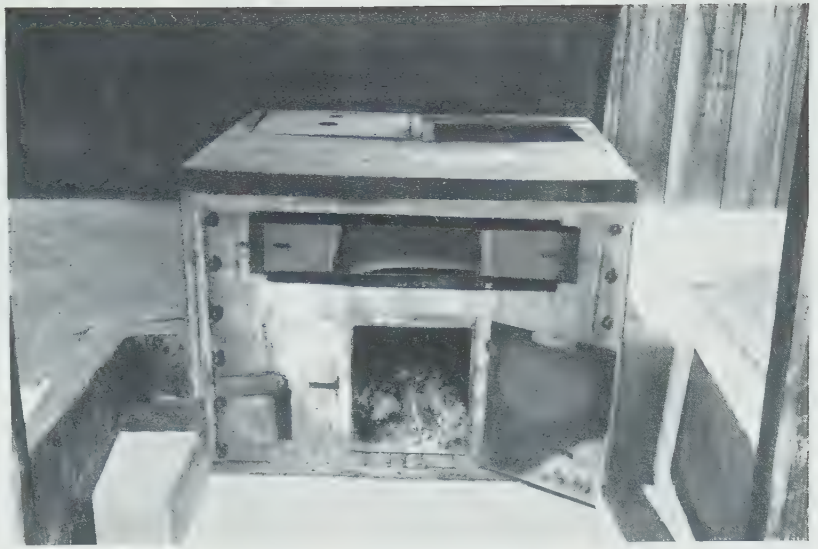


PLATE V

Furnace opened shewing Inner Arch.

sketch of this arrangement is shewn in Figure 9. This system was found to work excellently. By adjustment of the flue apertures and top ventilators it was found easily possible to obtain a temperature gradient of 20°F to 25°F along the house, and when they were once set these controls needed no further adjustment over a long series of tests, in which a number of different varieties of estate sheet were dried. There were no ventilators round the base of the walls and the only remaining adjustments necessary were the amount of fuel, amount of air admitted through the fire door, and the amount of air entering round the outside of the metal furnace arch. Sheet varying in thickness from 0.09 inch to 0.15 inch was all dried to a good medium brown colour in four days. The temperatures could be held remarkably steady, the furnace gave a good volume of smoke, and the outer brick structure kept much cooler than in the previous tests. In the experimental model no firebrick was used, the metal arch was only of 18 gauge galvanised sheet and the face-plate was of 1/8" mild steel. In spite of this flimsy construction the furnace has worked practically continuously for several months and remains in very good condition. A slight bulging of the furnace face-plate occurred in the earlier tests when the drum was used, but no further distortion appears to have occurred. Photographs of the experimental building in its final form appear in Plates I to V.

New Smoke-houses

As a result of these tests two smoke-houses have been designed for estate use and are described in an Appendix to this paper. The first follows very closely the experimental model, and is designed for a crop of up to 1,000 lb. per day. It is considered to have been tested thoroughly and can be recommended to estates. The second model is designed as a unit capable of drying 2,000 lb. of rubber per day. The principle is exactly the same, except that eight trucks are used on a single track, and in order to prevent the flues from becoming excessively long the wide short trucks, similar to those described in connection with the Beradin smoke-house, are employed. This model has not yet been put into operation, since the means for testing it are not available at the Experiment Station. The design is put forward however with some confidence; it is hoped that an estate will erect such a building on which tests can be made by the Institute for early publication. The fuel consumption in the experimental model is very slightly more than ½ lb. of wood per lb. of dry rubber produced, and it is confidently expected that this can be improved upon in the large unit.

These new smoke-houses offer several advantages over previous types. They can be built on sites where the water table is high. The initial cost for the building is low if timber and insulating board are used, and even with a brick building the cost is less than that of the Subur type. The furnace is of cheap and simple construction and can readily be renewed by the insertion of a spare steel arch. Such work would not require skilled labour. The operation is simpler than that of a Subur-type building, and the rubber produced is a much more satisfactory colour. The production of a well-smoked sheet is of particular importance if rubber is to be stored for any length of time, as the smoke tends to increase the resistance to mould attack.

In addition to the two new smoke-house designs put forward as a result of this work, the difficulty of obtaining an adequate volume of smoke, and a sufficiently dark colour on the sheet dried in smoke-houses with an exterior furnace, appears to have been overcome. The tendency has been to make such furnaces more and more massive, with the object of securing a longer life and reducing the proportion of heat lost to the outside air. Every increase in the thickness and insulating properties of the furnace walls has resulted in an increase of temperature of the inner surface of the furnace and in the heat capacity of the structure, until it has become common to find furnaces which require days to heat up to an equilibrium condition or to cool to air-temperature after the fire has been withdrawn. The exceptional wall-temperatures have rendered the use of refractory furnace linings necessary and have also made it very difficult to produce smoke. In spite of numerous experiments with various fuels, and alterations in the supply of primary air, any smoke produced from the wood becomes burnt up on striking the extremely hot furnace arch. These objections can be overcome by using a thin walled furnace but in that case the heat loss would be very large. The present design gives the thin cool furnace walls and at the same time transmits radiant heat to the ventilating air. The arrangement has the additional advantage that the ventilating air and hot gases from the combustion become mixed in the flue and enter the drying chamber together, thus tending to give a more uniform temperature distribution than the older method which admitted hot flue gases in the centre of the chamber, while cold air entered through ports in the side walls.

The principle of the steel inner arch separated from the main furnace structure with a stream of air passing between the two can easily be applied to the furnaces in existing Subur smoke-houses. Such a modification has not yet been thoroughly tested, but has already been recommended to a few estates, and sufficient confidence is felt to propose it for the consideration of

others who are not satisfied by the colour of sheet produced in smoke-houses of the Subur type.

Acknowledgments

The author is indebted to Dr. E. Rhodes, formerly Head of the Chemical Division, and to Mr. H. W. Foston, Manager of the Experiment Station, for their continued interest, advice and help in this work. Our thanks are also due to the General Manager of the Kepong (Malay) Rubber Company and his estate Managers for supplying representative samples of sheet rubber from various estates for our tests.

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Kuala Lumpur

15th September, 1938

APPENDIX

(To paper on Experiments with a New Type of Smoke-house)

R.R.I. TYPE SMOKE-HOUSES

TYPE A FOR CROPS UP TO 1,000 LB. PER DIEM

TYPE B FOR CROPS UP TO 2,000 LB. PER DIEM

BY

J. H. PIDDLESDEN

Introduction

The new R.R.I. type smoke-houses described herein are the result of a long series of experiments at the Rubber Research Institute. They are now recommended in preference to the Subur type on the grounds of lower initial cost, greater simplicity and ease of operation.

It will be noticed that timber and insulating board are suggested as suitable construction materials, since these give a cheap satisfactory structure, and it is felt that brick buildings have not justified their extra cost by reducing the fire risk sufficiently.

An entirely new furnace design has been produced. This is cheap and easy to construct, produces much more smoke than the usual outside furnace, and at present appears to give promise of a long working life. In any case the metal arch used can be removed and replaced with a new one in an hour with unskilled labour.

The furnace is designed to admit air between the metal arch and the surrounding brickwork. This not only keeps the brickwork cool, but preheats the air entering the smokehouse, and dispenses with the necessity of having numerous ventilators round the walls of the house.

PRINCIPAL FEATURES

The new R.R.I. type smoke-houses incorporate all the main advantages of the older Subur types, such as nearly continuous smoking, the avoidance of carrying sheet, low fuel consumption etc. They also exhibit the following improvements on the Subur type:—

1. No turntables are required. The trucks move straight through the tunnel-like building on a single track. The trolleys

carrying wet rubber enter at the end remote from the fire and are pushed along daily by the trolleys entering behind them, until after four days they emerge at the far end with the rubber completely dry. There is no withdrawing of the trucks and inserting them into a different compartment each day. Turntables will be required only if more than one house is built or if the site does not permit of a straight line from the factory to the packing shed.

2. Excavation is reduced to a minimum. The smoke-house can be built without modification on wet sites, provided that adequate foundations are constructed under the furnace.

3. An improved furnace. The new furnace is cheap to construct, easily repaired, and gives a better colour on the sheet.

4. Simplified control. Ventilators round the base of the walls are rendered unnecessary.

5. Cheaper construction.

6. Trucks are loaded from the side. Side-loading has been found to be quicker and easier than loading from the ends of the truck, and to offer no disadvantages in the drying.

7. Accessible flues. Flues can be opened along their entire length for inspection and cleaning.

8. Drainage. The trucks and floor are so designed that water dripping from the sheet is rapidly drained from the building.

Type A

Notes on Design

General

The unit of construction is a single tunnel-like building—about 36 ft. long and 8 ft. wide inside, with doors at each end, and is capable of holding four trucks on a single rail-track through the centre. The main flue enters from one side, and a branch flue runs the length of the building between the rails, with outlets under the centre of each truck.

Drying Time

There is no difficulty in drying normal estate sheet between one-tenth and one-eighth of an inch thick in three-and-a-half to four days. During tests, sheet of 0.15 inch thick was dried in slightly less than four full days. The finished sheet is of a good medium brown colour.

Capacity

Type A is intended for the small estate, with a daily crop of the order of 1,000 lb. The capacity can be varied within limits to suit individual requirements. For example, an extra seven inches added to the width of the truck will allow space for forty more sheets per day. A slight reduction in the spacing between *beroties* will also add appreciably to the capacity. Alternatively, if the crop is to be only about 700 lb. the top tier of *beroties* can be omitted and the height of the house correspondingly reduced. In this respect the importance of designing the truck to suit individual requirements cannot be over-emphasised. In the truck illustrated provision is made for wide sheets such as are obtained from 28-inch wide sheeting batteries. Two *beroties*, each four feet long, are placed end to end on the truck and arranged to carry two sheets each. If the sheet is only eighteen inches wide four sheets can still only be carried in line on the same truck, but there would be much waste space. If however, the centre supports were moved and one *berotie* four feet nine inches long carrying three sheets were placed on one side, the other *berotie* could be made three feet three inches long and would carry a further two sheets. The altered truck with the intermediate support placed off-centre would thus carry twenty per cent more sheets without any increase in over-all dimensions. Adjustments of this sort can be made without altering the fundamental design, or the sizes of the steel structural members in the truck.

It is not recommended that more than about 1,200 lb. of rubber be placed on a single truck.

Flexibility of Design

Where the crop is small and will not increase for some considerable time a Type A smoke-house can be built, and later extended or duplicated. To extend this type, the wall on the side remote from the furnace can be utilised as a partition wall between two tunnels. If this wall is of planks with an inner wall of asbestos-cement boards the planks can be removed and replaced by a second layer of insulating board. The wood can then be re-used in the construction of the extension. If this method be adopted there must be space for a wide sweep of the return rail, to clear the second furnace. If therefore a crop of the order of 2,000 lb. per day is confidently anticipated in the near future, it is recommended that a Type B smoke-house be built in the first instance.

Temperature Control

The importance of increasing the temperature as drying progresses is well known. It has been found possible by

adjustment of the flue outlet apertures and roof ventilators, to maintain a practically constant temperature gradient along the tunnel. Thus if a suitable thermometer is placed near the furnace end where it can be observed by the labourer responsible for the firing, and this is kept steady, the temperature at the other end will also be steady and lower by a constant amount. Once the flue outlets and top ventilators have been adjusted properly they can be left alone for long periods and all control exercised from the furnace.

Drainage of Water

Baffles are provided on the trucks, and drains are so arranged in the floor that water dripping from the sheet is thrown clear of the flues and rails and is drained out of the building.

Notes on Construction

Structure of Building

The building may be constructed of brick, or of reinforced concrete pillars with the walls filled in with precast hollow blocks or slabs. It is suggested however that a hollow wall, with planks on the outside and a lining of some suitable composition board is cheaper and sufficiently permanent for all practical purposes. If this construction is used it is important that the cavity be sealed in order to obtain good insulation. This can be accomplished by embedding the base of the wall in the concrete floor. At the top the inner wall must be arranged to make a close joint with the ceiling and any gap between the outer wall and the roof must be sealed as well as possible with planks. Rough-sawn overlapping planks are suggested for the outside walls. These must be placed with an overlap of at least one inch to ensure that gaps will not appear as the wood shrinks. For the lining asbestos-cement or Uralite boards are suggested. They are cheap, fireproof, non-porous, and resistant to insect attack. They are only fair insulators of heat and are brittle. There are other types of proprietary boards available, which may be considered. These fall into two classes, insulating boards and building boards. The former are soft, and not brittle, they are thick and are very good insulators for heat. They are all inflammable and most of them absorb water readily, losing their rigidity. The building boards are hard, non-porous and fair insulators of heat. They are not brittle but are all inflammable. Since the inner walls and ceiling are not likely to be subjected to impact shocks, brittleness is no disadvantage, but for lining the doors, which may be struck by the ends of the trucks, a non-brittle material is recommended.

Roof

The roof may be of corrugated iron or asbestos with a ceiling of asbestos or similar board. This ceiling should be airtight and should follow the slope of the roof. An ordinary piston type ventilator, as described for the Subur smoke-house, is used over the centre of each truck.

Doors

The doors should be airtight, strongly constructed, and well hung. The insulation of the doors is not quite so important in this type as it is in the Subur type, and cavity doors are thought to be unnecessary. Hard-wood planks three-quarters of an inch thick, and well butted together are suggested for the main panels. The joints can be covered on the outside with light beadings giving a good overlap on each side, if desired. If the beadings are used the door should be fairly air-tight, but even so, a lining of plywood or some suitable composition board as mentioned above is desirable, in case the door warps and splits. If no beadings are used a good air-tight lining is essential.

Floor and Flues

The floor is constructed of concrete, in which the rails are embedded. The distributing flue between the rails is in the form of an open trench with a concrete floor and brick side walls rendered over with cement. It is one foot wide throughout and is one foot six inches deep at the junction with the main flue, rising to one foot deep at both ends. It is closed by light precast slabs, reinforced with expanded metal, and preferably provided with rings for easy lifting. Each slab is designed with lips which overlap and seal the joints with its neighbours. Four apertures one foot square are left, one under the centre of each truck. These can be covered with expanded metal embedded in the concrete, which will serve to support small concrete blocks or pieces of asbestos board, which can be used to adjust the size of the outlet. The floor slopes from the rails down towards each side wall, and just inside the wall a small drain is made to slope down towards the doors at the end remote from the furnace. The incoming flue is eighteen inches square and is constructed in the same way. It enters the house at one side at a point one-fourth of the length from the exit end, *i.e.* between the positions of the third and fourth trucks. Thresholds should be provided to seal the lower edges of the doors.

Entry of Flue **(Important)**

If a timber structure is used it is very important to protect the wall where the inlet flue passes under it. To do this a section

of wall at least three feet wide and one foot six inches high, should be constructed of brick or concrete, immediately over the flue.

Furnace

An entirely new furnace design has been evolved. Previously the tendency has been to make the furnace walls very thick to prevent heat loss to the air. In this respect the designs have succeeded, but the resulting structures have been massive with a very high heat capacity and high inner wall temperatures. The inner walls become hot enough to burn virtually all the smoke produced from the fuel. A thin-walled, poorly-insulated furnace produces smoke but dissipates much heat to the air.

In the new arrangement a thin-walled furnace is enclosed in an outer case and the heat radiated from the outside surface of the furnace arch is collected by a stream of air which passes between it and the case, and thence into the smoke-house. A sheet steel furnace arch is used which tapers down to fit the flue entrance. The outer structure is a simple box with the side walls of single brick and the top of reinforced concrete. The front is closed with a face-plate which is bolted on, and carries the furnace door and two adjustable ventilators, one on each side, to admit air between the fire arch and outer case. A hole is cut in each lower rear corner of the arch to allow this air to mix with the smoke and enter the flue. The steel arch is not secured in any way, it stands on the floor of the fire-box, and it is therefore free to expand and contract. Large bolt-holes are used on the face-plate which is not secured too tightly, so that it is free to expand. This prevents buckling. The whole face-plate is readily removable to permit inspection or renewal of the arch. Two or three bars are placed across the arch to act as a fire stop and to prevent fuel being pushed right into the flue. An ordinary concrete floor can be used in the furnace but a covering of fire-brick improves it.

Trolleys and Rails

A rail gauge 2 feet 6 inches wide is suggested as this gives greater stability to the truck, and keeps the rails well clear of the flue. A 2-feet-wide gauge can however be used if desired, and is quite sufficient if the truck is designed to carry only 700 lb. of sheet. It is particularly important that the rails in the smoke-house be very carefully levelled, since it is desirable that three trucks can be moved along together by pushing at one end. The trucks are designed for side-loading. The *berotics*, which may be of bamboo, are spaced at 3½-inch centres, and are each 1¼ inches thick. The increased thickness and spacing are used since it has

been found in practice that the usual 1-inch-thick *beroties* 3 inches apart are not sufficient to prevent the sheet from sticking together and delaying the drying. For an estate which desires to load 1,200 lb. of rubber per truck, the closer spacing can be used to prevent the truck becoming too large, but in this case it may be advisable to turn the sheet after the first 24 hours. Turning should be unnecessary with the normal truck. A thin sheet metal domed baffle 3 feet wide runs along the centre of each truck. This serves the double purpose of spreading the smoke and draining off to the sides any water dripped from the sheet.

Notes on Operation

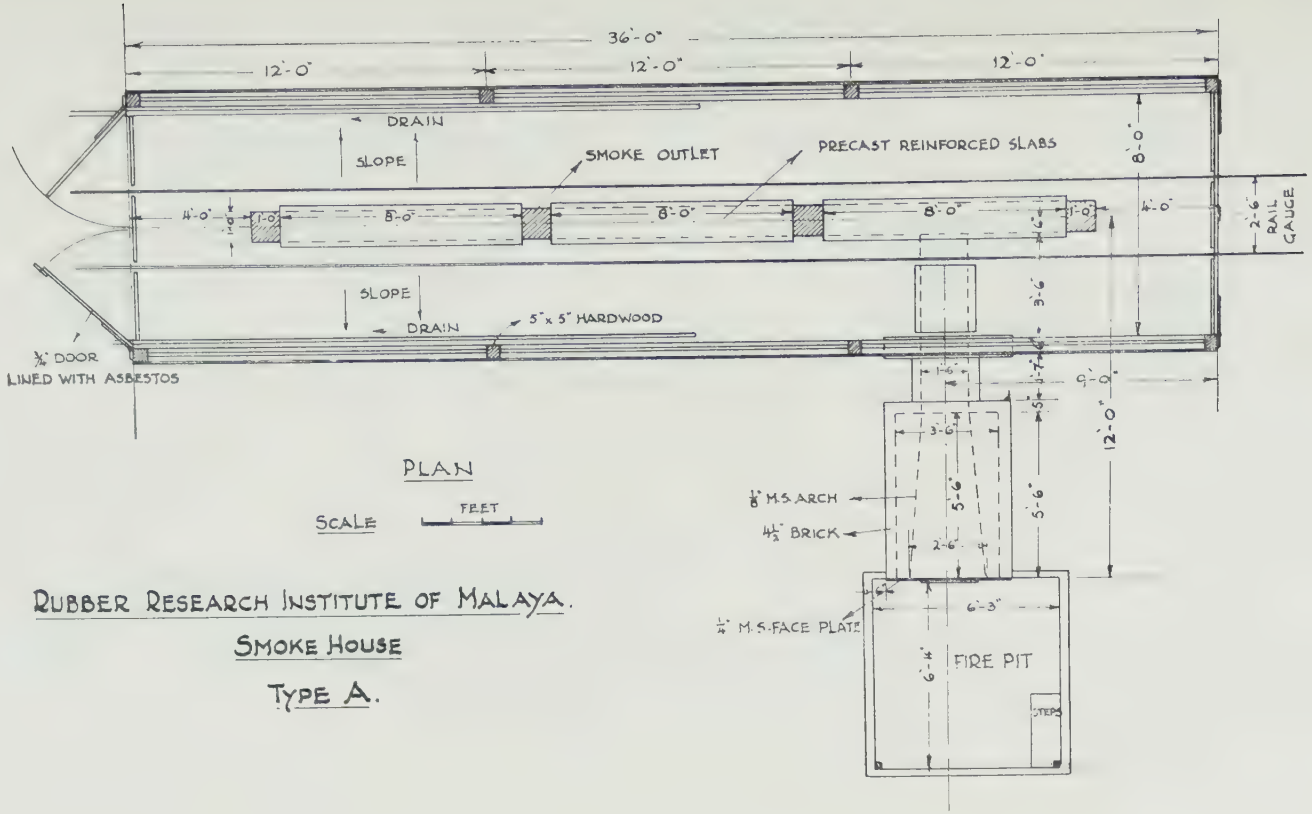
The settings required on the ventilators and flue outlets will vary according to the local conditions, and a few experiments will be required. The following procedure is suggested:—

(1) Leave the flue outlet and top ventilator at the end containing the wet rubber wide open.

(2) Adjust the fire and air inlets on the furnace face so that a temperature of 115°F and a good ventilation are obtained through the end truck.

(3) Vary the flue aperture and top ventilator settings for the remaining three trucks until temperatures of 125°, 135° and 140° are obtained in these while that of the end truck remains at 115°F. Since the construction differs from that of the Subur, in that the main flue enters between the third and fourth trucks, it will be found that these settings are not progressive and that a smaller smoke outlet may be required under the third truck than under the fourth.

When these adjustments have been made the smoke-house will require very little attention. A thermometer should be provided near the fourth truck and the labourer taught to adjust the firing to keep this steady at 140°F. A convenient form of thermometer is one operated by a mercury bulb connected by a capillary tube to a dial mounted outside the house near the firebox. Such instruments can be purchased in England for approximately £2.10.0, and while they do not furnish a recorded temperature chart, they are extremely useful for control purposes since the bulb can be placed in the centre of the building and the labourer can be taught to keep the pointer at any selected mark on the circular dial.



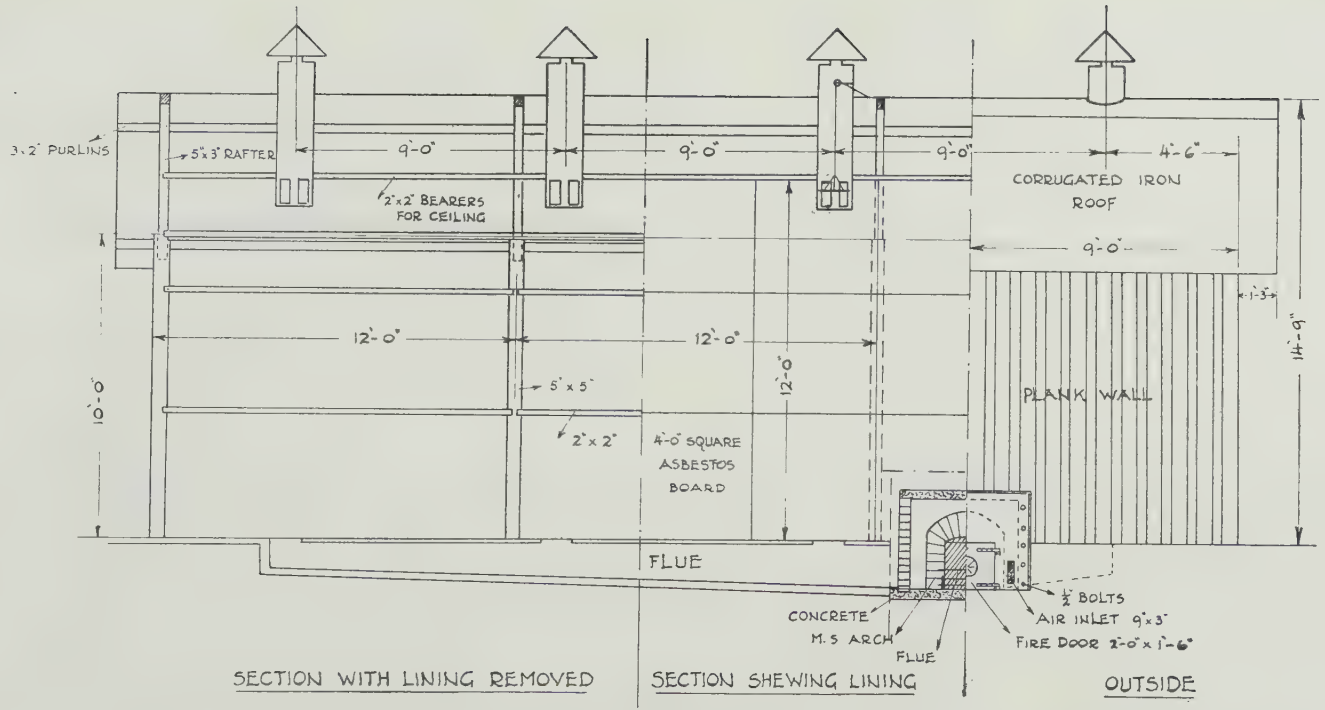
PLAN

SCALE FEET

RUBBER RESEARCH INSTITUTE OF MALAYA.

SMOKE HOUSE

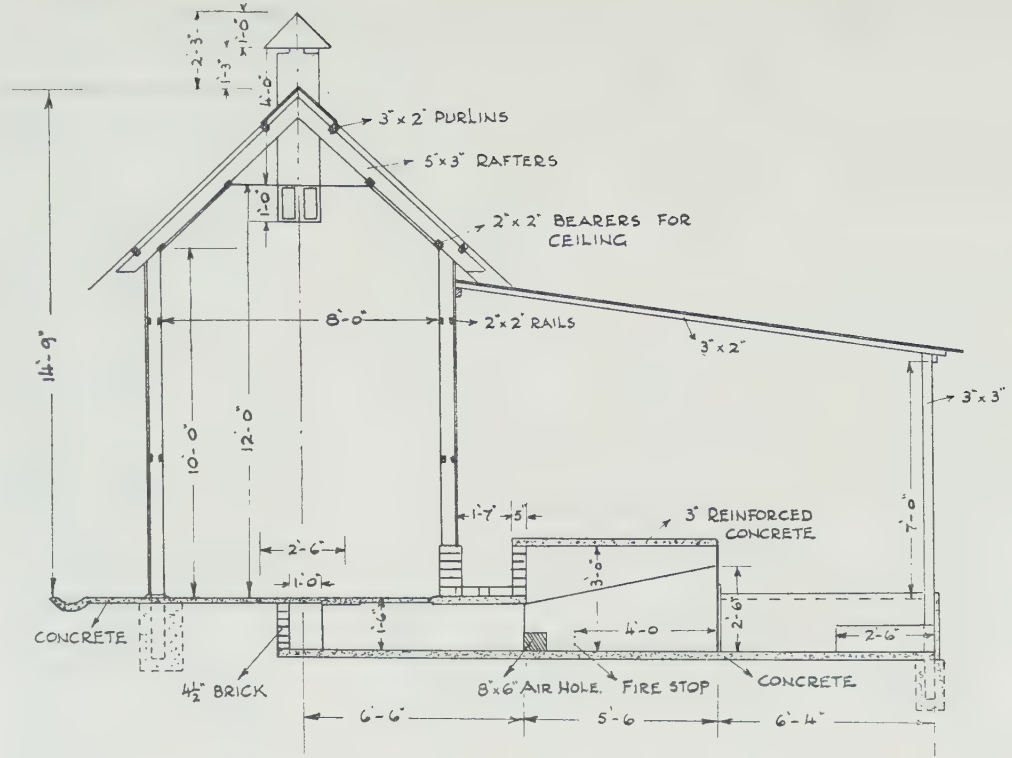
TYPE A.



ELEVATION

SCALE FEET

R.R.I. SMOKE HOUSE TYPE A.

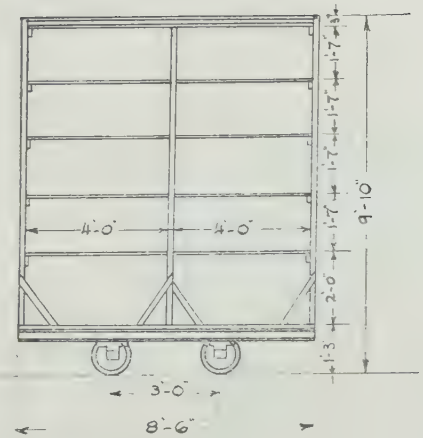


END ELEVATION

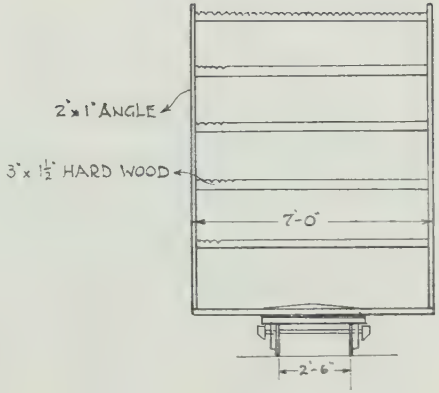
SCALE FEET

R. R. I. SMOKE HOUSE

TYPE A.



ELEVATION



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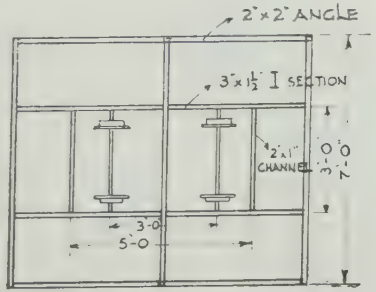


PLAN

SCALE FEET

TRUCK FOR TYPE A SMOKE HOUSE.

CAPACITY

BROTIES 4'-0" LONG x 1½" DIAMETER. 2 SHEETS PER BROTIE.

BEARERS 7'-0" LONG GROOVED AT 3½" CENTRES. 24 BROTIES PER ROW.

FIVE TIERS OF BROTIES, 480 SHEETS i.e. 960 LBS. AT 2LBS. SHEET OR 1080 AT 2¼LBS SHEET.

WITH BROTIES AT 3" CENTRES 560 SHEETS i.e. 1120 LBS AT 2 LBS SHEET OR 1260 AT 2¼LBS. SHEET.

WITH 4 TIERS OF BROTIES AT 3½" CENTRES CAPACITY IS 384 SHEETS.

WITH 4 TIERS OF BROTIES AT 3" CENTRES CAPACITY IS 448 SHEETS.

STRUCTURE

BOGEY - TWO 3"x1½" I SECTION BEAMS CONNECTED BY TWO CROSS MEMBERS OF 2"x1" CHANNEL.

MAIN FRAME - ALL 2"x 2"x ⅛" ANGLE.

TIES - 1½"x⅛" BARS.

BROTIE BARS 3" x 1½" HARD WOOD.

BAFFLE - 1½"x⅛" MS BAR FRAME COVERED WITH 28 SWG SHEETS.

TYPE B

Notes on Design

General

The unit of construction is a single tunnel approximately 52 feet long and 11 feet wide inside and capable of holding eight trolleys on a single rail-track through the building. There is a main distributing flue between the rails with an outlet under the centre of each truck. Four days are allowed for drying.

Capacity

Type B is intended for the average estate with a crop of approximately 2,000 lb. per day. The capacity can be varied within limits to suit individual requirements, but it is not recommended that the building be enlarged much beyond the suggested sizes. Increased capacity can be obtained by spacing the *beroties* slightly closer together. If narrow sheet is manufactured the length of the trucks may be increased slightly to allow four sheet to be hung on a single bar. This increase should not however exceed six inches per truck. As in Type A it is important to design the truck to suit the actual width of sheet manufactured, but in making alterations the overall length of the building must be kept to a minimum or the flue may become too long to be effective. Here again 1,200 lb. is suggested as the approximate maximum dry weight of rubber suitable for a single truck.

Flexibility of Design

Two such tunnels can be constructed side by side with a common partition wall, and will suffice for a crop of 4,800 lb. per day. If this crop is to be exceeded an entirely different arrangement of smoke-houses would probably prove more economical, and persons interested in the construction of very large drying installations are recommended to consult the Rubber Research Institute.

Temperature Control and Drainage of Water

The notes under these headings for Type A are equally applicable to Type B.

Notes on Construction

Structure of Building, Roof, Doors and Floor

The remarks concerning the construction of the roof, walls, floor, and doors, in connection with type A apply with equal force to the larger unit.

Flues

These are constructed in the form of open trenches as described for the type A smoke-house, but are larger. The incoming flue is 2 ft. deep by 1 ft. 6 inches wide. The long branch of the distributing flue is 1 ft. 6 ins. wide, and 2 ft. deep at its lowest point rising to 1 ft. deep at the end. It is provided with six outlets, one under the centre of each truck, each outlet being 1 ft. 6 ins. square. The short branch is also 1 ft. 6 ins. wide, but is only 1 ft. 6 ins. deep at its junction with the incoming flue and rises to 1 ft. deep at the end. This branch has two outlets 1 ft. 6 ins. square, one under the centre of each truck. The flues are covered in with precast slabs as previously described.

Furnace and Entry of Flue

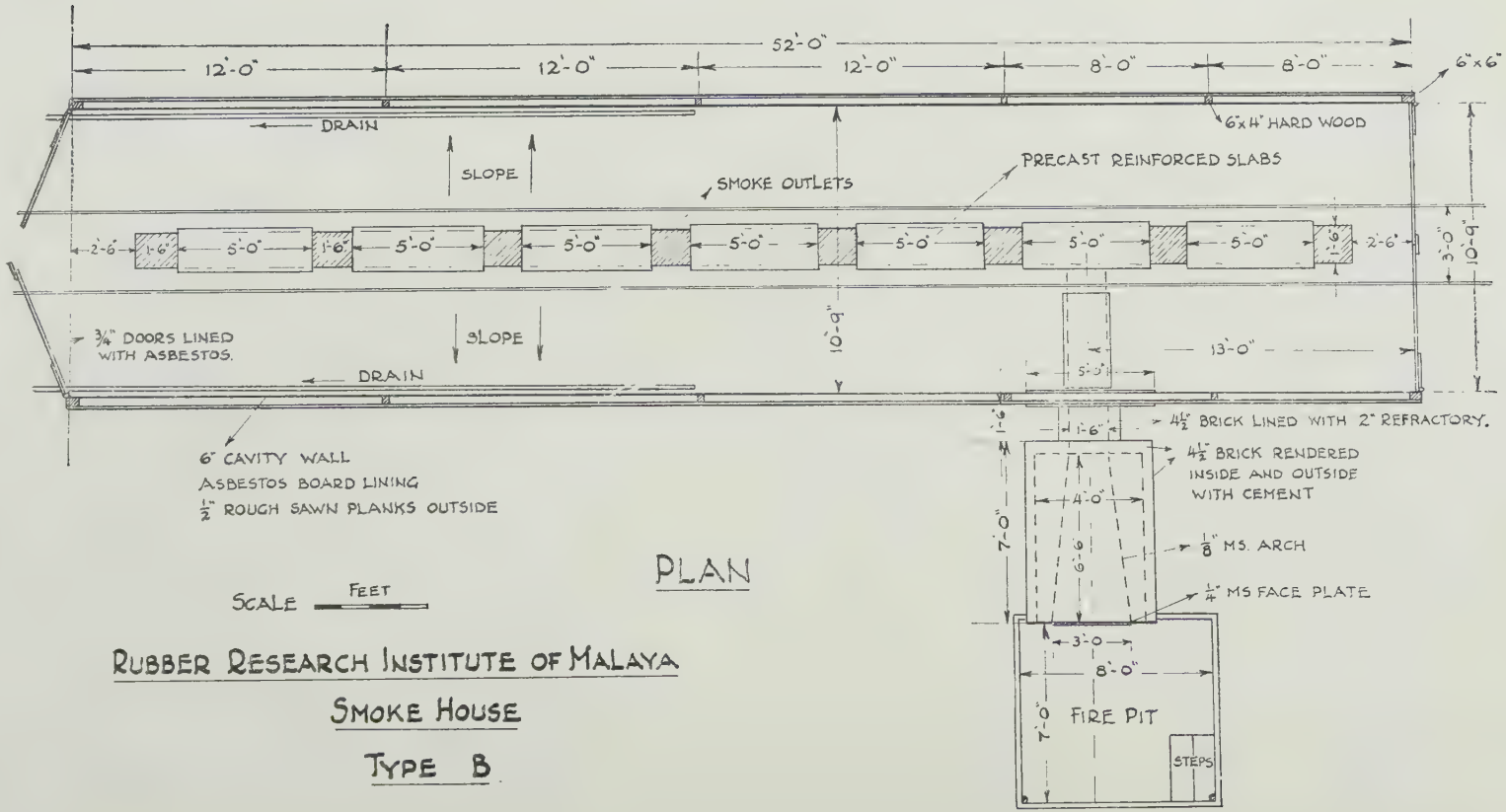
The furnace follows the design outlined for the smaller model, but is made somewhat larger and heavier. In this case the furnace floor is 2 feet below ground level. The furnace should be well supported if it is to be placed on wet land, otherwise it will sink as the ground beneath it dries out. In this larger model it is preferable to line the furnace floor, the back wall and the first few feet of the incoming flue with firebrick or some suitable refractory composition. It is again important that the side wall of the building be adequately protected at the point where the flue passes beneath it.

Trolleys and Rails

Eight trolleys are used on a single rail-track of three feet gauge. In order to prevent the building from becoming excessively long the trolleys are made very wide in comparison with their length. *Beroties* $1\frac{1}{4}$ inch thick at $3\frac{1}{2}$-inch centres are again recommended. The short wide trucks appear unconventional but if they are well constructed they are perfectly stable. Domed sheet metal baffles are used along the centre of each truck to throw off any dripped water. Thin sheet of 28 S.W.G. is adequate for this purpose, but the baffles should be painted to prevent corrosion and should be adequately supported to bear the weight of a labourer who may walk on them while loading. In this type of building particular care should be exercised in setting the rails accurately and ensuring that the wheels and bearings are good, since, when the two trucks of dry rubber have been removed, it is desirable to be able to move the remaining six along inside the house, by pushing from the far end. Also if this procedure is adopted care should be taken to prevent the trucks from striking the far door. This can be done by using a detachable stop.

Operation

As was stated in the paper to which this appendix relates, the R.R.I. type B smoke-house has not yet been put into commercial operation. It is expected to work as satisfactorily as the smaller model, and a report on actual tests will appear as soon as possible.



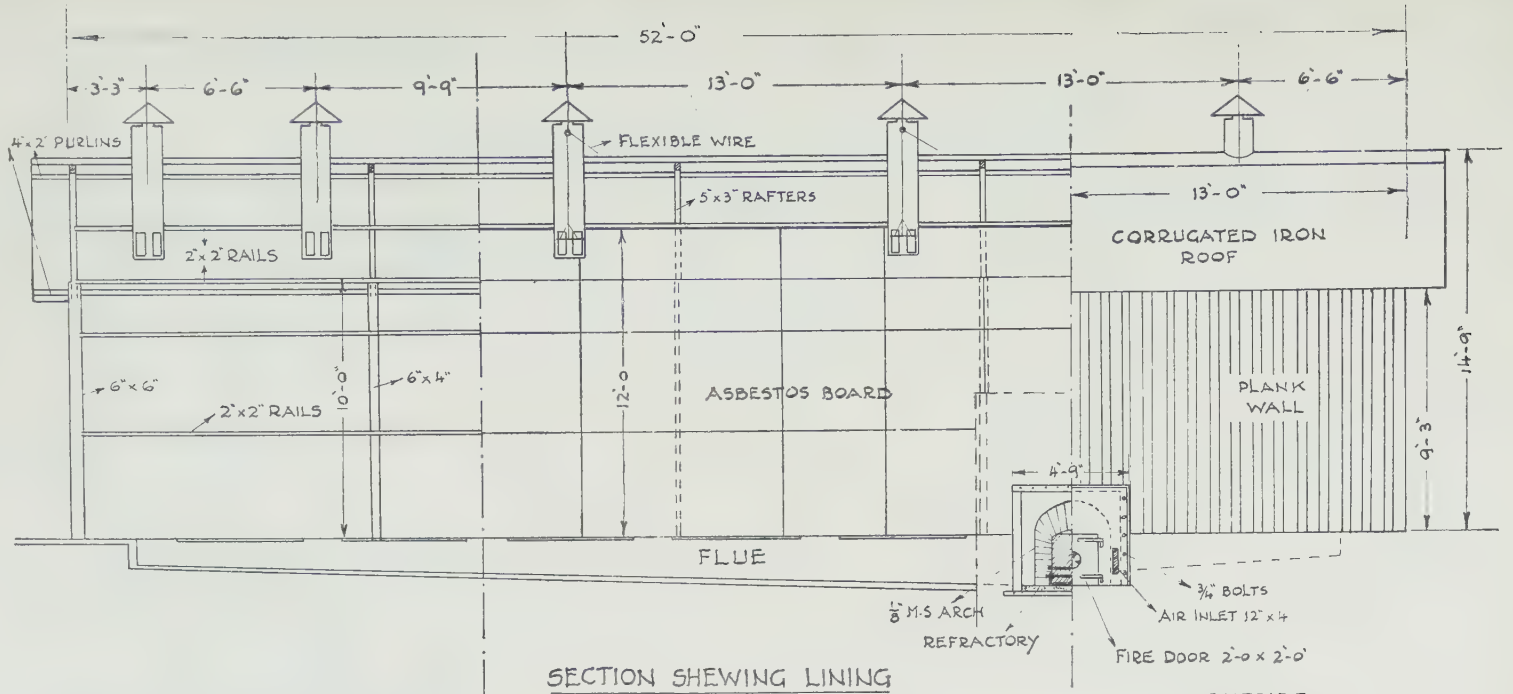
PLAN

SCALE FEET

RUBBER RESEARCH INSTITUTE OF MALAYA

SMOKE HOUSE

TYPE B



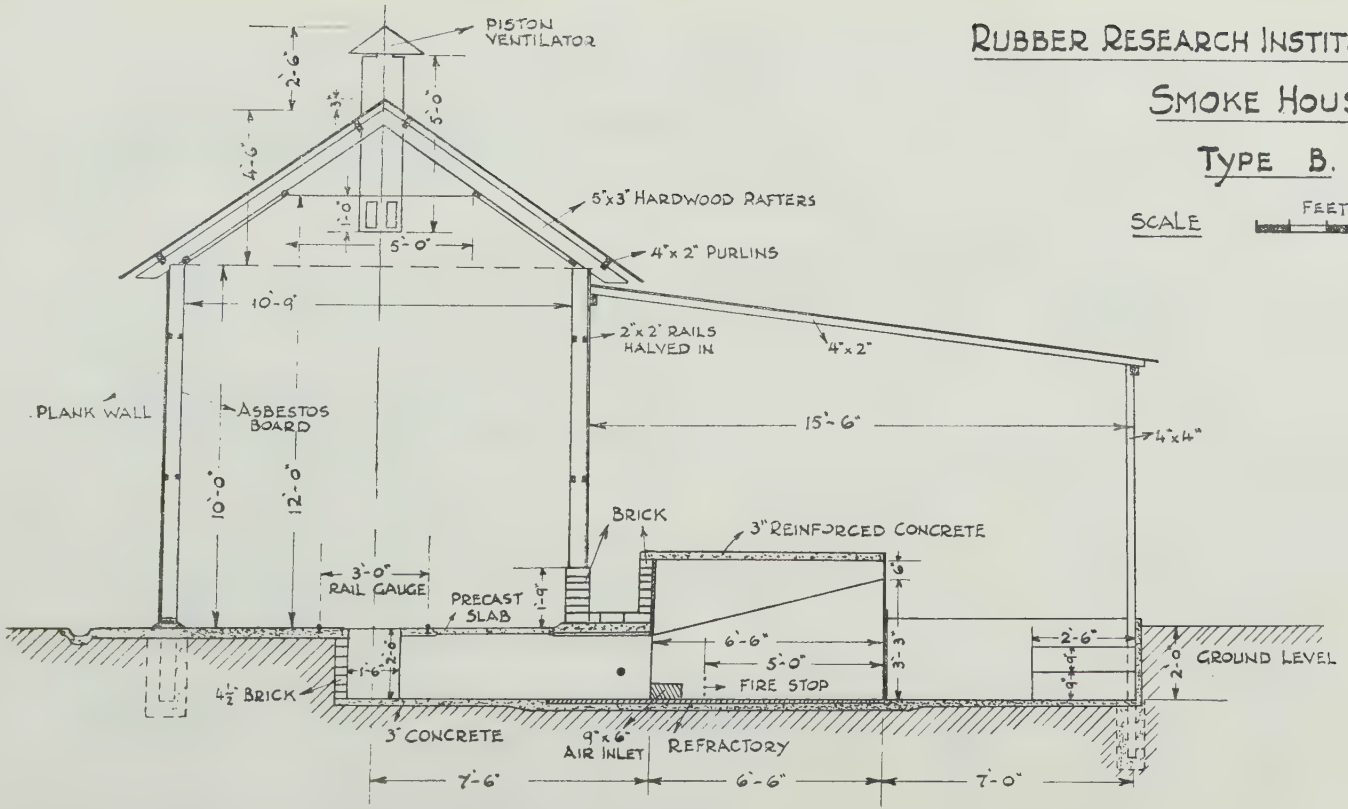
R. R. I. Smoke House Type B.

RUBBER RESEARCH INSTITUTE OF MALAYA

SMOKE HOUSE

TYPE B.

SCALE FEET.



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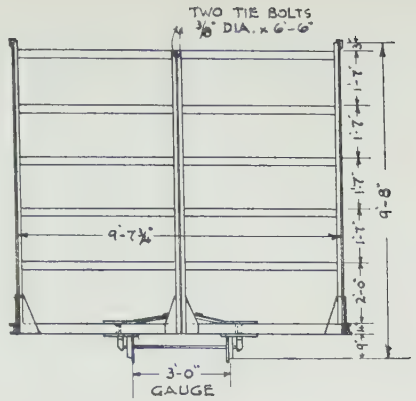

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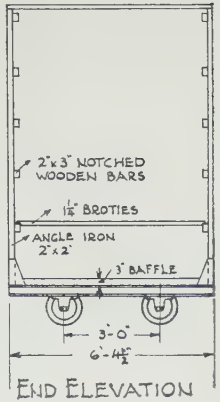

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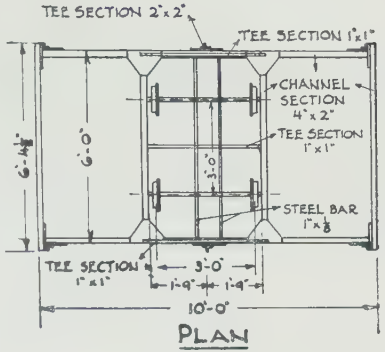

PLAN

SCALE FEET

TRUCK FOR TYPE B SMOKE HOUSE.

CAPACITY

BROTIES. 6'-0 LONG 5'-8" OF CLEAR HANGING SPACE i.e. 3 SHEETS UP TO 21" WIDE PER BROTIE.

SIDE BARS. NOTCHED AT 3 1/2" CENTRES. 34 NOTCHES.

HEIGHT FIVE TIERS OF BROTIES AT 1'-7" CENTRES.

CAPACITY. 5 x 3 x 34 = 510 SHEETS UP TO 21" WIDE. BY 3'-0" LONG. i.e. 1020 LBS WITH 2 LB SHEET OR 1150 LBS WITH 2 1/4 LB SHEET.

STRUCTURE

MAIN FRAME MEMBERS. CHANNEL SECTION 4"x2 7/16"

CORNER UPRIGHTS. ANGLE SECTION 2"x2"x 3/16"

CENTRE UPRIGHTS. TEE SECTION 2"x2"x 1/4"

CROSS BAR AT SIDES AND TOP. ANGLE SECTION 1 1/2" x 1 1/2" x 1/8"

BAFFLE FRAME CROSS MEMBERS. TEE SECTION 1" x 1" x 1/8"

BAFFLE FRAME TIES. FLAT SECTION 1" x 1/8"

A Warning

DANGEROUS BALE-STRAPPINGS FOR RUBBER

It has come to the notice of the Institute that consignments of baled rubber, strapped with copper-plated steel strapping bands, have recently been shipped from Malaya.

Copper should, on no account, be allowed to come into contact with rubber because it induces very pronounced tackiness and impairs the properties of rubber very seriously. The copper plating on a bale strap is very dangerous for this reason.

Plain unplated steel straps are quite satisfactory for rubber bales and should be used exclusively; plated straps should, on no account, be used.

The attention of all those engaged in baling rubber is drawn to this warning and they are earnestly requested to act upon it forthwith.

E. R.

Kuala Lumpur

1st June, 1938

PLASTICITY AND THE COLOUR OF SHEET RUBBER*

BY

J. D. HASTINGS

Introduction

Figures showing the amount of crude rubber exported from the producing countries indicate that the consumer still receives approximately 95 per cent of his raw material in the form of sheet or crepe. Except for those processes which do not involve compounding on the mills, this crude rubber has to be reduced to a plastic condition before it can be compounded. The time and power consumed in the preliminary mastication are matters of considerable economic importance. The more variation there is in the hardness of the raw material the more difficult is it to standardise the processing. In order to overcome this the manufacturer is compelled to adopt some method of blending his supplies, or to resort to selective buying so as to smooth out irregularities in individual consignments. The plasticity of raw rubber is therefore still an important matter to the consumer, and it is unfortunately one of those physical properties over which the producer can exercise little control unless he is aware of the factors which will affect his produce. For in contrast to those defects apparent to visual examination, he has no means of ascertaining whether his rubber is likely to prove soft or hard.

During the last few years many changes in estate factory practice have taken place. As a result of improvements in the machining and drying of the coagulum, smoked sheet now tends to differ from that produced in the past. Coincident with these changes there has been a certain amount of complaint from some manufacturers concerning plasticity. It is therefore pertinent to inquire if these complains can be attributed to the changes made by the producers. The changes are most noticeable in the thickness and colour of the sheet produced. No. 1 Ribbed Smoked Sheet is now generally lighter in colour and thinner than that formerly made on European estates. It does still vary from the light golden colour of very lightly smoked sheet to the deep amber and dark shade which was almost universal in the past. So far as can be ascertained there has been no suggestion that the thinner sheet is less acceptable, but it has been stated that the light is harder and more difficult to masticate than the dark sheet.

* This paper was presented at the Rubber Technology Conference, London, May 23-25, 1938.

An investigation is in progress at the Rubber Research Institute of Malaya on the subject of plasticity and its variation in raw rubber. The results recorded in this paper however are concerned only with the relationship between the colour of sheet rubber and its plasticity.

Previous Work

Discussing the variable preparation-factors of crude rubber which can influence plasticity, Elliot (1) states that it is very probable that the temperature of drying has some effect and that smoked sheet would be expected to be softer than air-dried sheet. From experiments made on sheets smoked for various times, he found that the smoking process had a definite softening effect on the rubber to the extent of about 25 per cent, although no appreciable difference was found between rubbers smoked for nine and fifteen days. The suggestion was made at this time that the considerable variability found among smoked sheet might be due to the temperature at which drying took place. Martin (2) mentions in a paper on the evaluation of raw rubber that estates are finding difficulty in obtaining firewood for the smoking process. He also says both the producer and the manufacturer have to face the problem of deciding whether it is really necessary to dry sheet rubber in smoke to obtain as good quality as that normally expected. From the plasticity measurements made he concludes that air-dried sheet requires about 15 per cent more mastication than smoked sheet. It is not clear whether this statement refers to sheet dried at atmospheric temperatures or at temperatures similar to those normally used in estate smokehouses; most probably to the latter, however.

Martin, Davey and Baker (3) carried out laboratory investigations on the variations in plasticity of crepe and sheet received in London from a number of estates in Ceylon. They mention that the opinion is held in rubber factories that dark sheet is soft and light sheet is hard. From the figures given they maintain there is a definite tendency for the light sheet to be harder but they state also that colour is not a reliable indication of the hardness of the raw rubber.

As a result of considerable trouble in the factory during processing, Young and Ruch (4) investigated the properties of two consignments of sheet rubber. Both were apparently of first-class quality but differed in colour, the one being light and the other dark. Their results clearly show the light sheet to be harder and to require more mastication than the dark sheet. In a subsequent paper (5) the same authors describe experiments in which the two rubbers were compared in all processing stages from raw

rubber to a final test in the form of tyres on the road. They found the outstanding difference to be the difference in plasticity which persists throughout the operations and causes difficulties in processing. When the light sheet was given a preliminary mastication sufficient to bring it to the same plasticity as its darker counterpart, these difficulties disappeared, and the final road-test of the tyres made from the two rubbers showed them to be alike. The authors mention that they had been able to ascertain that the light-coloured sheet was declared to be "air-dried-sheet and smoked-sheet having a very light smoke." In commenting on the apparent scarcity of material for smoking purposes, they too sound a warning to the manufacturer. They consider that in the future he must be prepared to accept sheet which is much lighter in colour than that which he has been accustomed to purchase in the past. It is undoubtedly true that a considerable quantity of sheet-rubber is to-day leaving the producer, and probably more from the Malayan producer than from the others, which is of much lighter colour than that formerly exported.

Experimental

About eighteen months ago samples of sheet were collected from a large number of big European estates in Malaya representive of the sheet normally produced on these estates. The samples were drawn from the produce made from the latex harvested on the same date on all the estates. Although climatic conditions are not uniform throughout the country, the seasonal factor, which is reported to be of little importance (3) was thereby eliminated from the comparison. Great variation in the colour of the sheet was observed. It varied from the deep brown to black colour of heavily-smoked sheet, to a bright golden colour, almost indistinguishable from that of sheet dried completely in hot air. Plasticity determinations were made in a Williams plastometer. No correlation of any kind was observed between depth of colour and plasticity. Further work was in progress on this investigation when the fire which occurred at the Institute in 1936 destroyed almost all the relevant records together with the samples. It has not been possible until quite recently to undertake another investigation of a similar nature, but this has now been done. Samples were again collected from the crop of the same date on the estates concerned, and classified according to colour. The classification was based on the colour-standards ruling on the Singapore market. No. 1 Ribbed Smoked Sheet is there divided into three colour-classes, light, medium and dark. From the information given by those who kindly supplied specimens falling

into each of these classes, it was learnt that the market generally prefers the medium grade. The producer is not penalised if his sheet falls into the light class, but he might not receive top market price if his sheet were heavily over-smoked. The estate managers from whom these samples were obtained were asked to give the approximate output figures for their estates. Table I gives the percentages of the number of contributing estates from which light, medium and dark sheet samples were supplied respectively, together with the percentages of the total weight of sheet, produced in each class.

TABLE I

Colour Distribution

	Light Sheet	Medium Sheet	Dark Sheet
Percentage Number of Estates ...	19.5	66.8	13.7
Percentage of total output of contributory estates	20.0	65.0	15.0

Although the number of estates from which rubber was obtained is small, it is representative of the estate plantation industry. It is computed that the estates concerned in the investigation are producing 10 per cent of the total weight of sheet rubber leaving Malaya. It is therefore evident that there is a good deal of very light-coloured sheet now being exported, which in many cases differs only slightly in appearance from hot-air-dried sheet and which must be similar to that found by Young and Ruch (*loc. cit.*) to be difficult to handle.

The plasticity of these samples was examined with the Williams plastometer shortly after they were received. The conditions of the test are similar to those used by De Vries (6) and later by Martin, Davey and Baker (3). A spherical pellet of rubber weighing exactly 0.4 grammes is compressed under a load of 5 kg. for 30 minutes at 100°C. The thickness in mm. to which such a pellet is compressed is recorded as the D_{30} value. The results are given in Tables II, III, and IV for the three classes. The average D_{30} figure for all the samples examined is 1.46, which agrees very well with that of 1.43 found by De Vries (7) as the average of a series of determinations on 84 estate samples varying in age from a few months to six months.

A short time ago, a new type of plastometer—the Mooney shearing disc instrument—was produced and described by Mooney (7). The treatment to which the rubber is subjected whilst its

plasticity is under measurement with this instrument more closely resembles that which it receives when on the mixing rolls, than is the case with the compression type of instrument. It is considered that the results obtained with this plastometer on raw rubber are a better measure of the plasticity than are the hardness figures given by the Williams type. The samples were therefore tested on a Mooney plastometer and the results also appear in Tables II, III, IV.

It is therefore not possible to detect in these data any tendency for one colour of sheet to be more or less plastic than another.

TABLE II

Plasticity Values for Light-Coloured Sheet

Sample No.	Plasticity		Sample No.	Plasticity	
	D_{30}	Mooney Value		D_{30}	Mooney Value
H 5001	1.30	67	H 5036	1.44	74.5
H 5002	1.40	72.5	H 5039	1.47	71
H 5004	1.46	77	H 5042	1.38	63
H 5013	1.51	77.5	H 5047	1.39	73.5
H 5015	1.46	64	H 5051	1.59	74.5
H 5019	1.52	68.5	H 5078	1.40	65.5
H 5022	1.35	64	H 5083	1.41	71
H 5027	1.47	79.5	H 5084	1.45	72
H 5032	1.51	71			

Average D_{30} 1.44
Average Mooney Value 71

TABLE III

Plasticity Values for Medium Sheet

Sample No.	Plasticity		Sample No.	Plasticity		Sample No.	Plasticity	
	D_{30}	Mooney Value		D_{30}	Mooney Value		D_{30}	Mooney Value
H 5001	1.42	68	H 5030	1.51	69	H 5062	1.38	72
H 5003	1.51	70.5	H 5031	1.53	72	H 5063	1.40	76
H 5005	1.44	71	H 5033	1.52	67.5	H 5064	—	67
H 5006	1.52	72	H 5034	1.43	73	H 5065	1.46	71.5
H 5007	1.38	64.5	H 5037	1.30	68	H 5066	1.40	75
H 5008	1.63	80.5	H 5038	1.37	65	H 5067	1.46	86.5
H 5009/1	1.43	65	H 5040	1.49	69.5	H 5069	1.58	79
H 5009/2	1.50	75	H 5041	1.41	71.5	H 5071	1.43	72.5
H 5010	1.39	70	H 5043	1.52	71	H 5073	1.41	70
H 5011	1.51	72	H 5044/1	1.49	68	H 5074	1.38	74.5
H 5012	1.43	66	H 5045	1.39	67	H 5075	1.60	84.5
H 5014	1.56	69.5	H 5046	1.48	71	H 5077	1.44	67
H 5016	1.53	74.5	H 5048	1.42	70.5	H 5079	1.43	66.5
H 5017	1.41	66.5	H 5050	1.42	71	H 5080/1	1.45	67
H 5018	1.47	74.5	H 5052	1.60	78	H 5080/2	1.50	77.5
H 5021	1.46	67	H 5055	1.50	72.5	H 5080/3	1.51	74.5
H 5023	1.41	64.5	H 5056	1.28	60	H 5081	1.46	71
H 5024	1.66	86.5	H 5057	1.40	69.5	H 5082	1.54	74.5
H 5025	1.47	68.5	H 5059	1.28	68.5	H 5085	1.53	73
H 5026	1.48	67	H 5060	1.42	67	H 5086	1.55	—
H 5028	1.45	72	H 5061	1.58	82			

Average D_{30} 1.46
Average Mooney Value 71.5

TABLE IV

Plasticity Values for Dark-Coloured Sheet

Sample No.	Plasticity		Sample No.	Plasticity	
	D_{30}	Mooney Value		D_{30}	Mooney Value
H 5020	1.45	71.5	H 5054	1.60	74.5
H 5029	1.51	73.5	H 5058	1.45	76.5
H 5035	1.51	76	H 5068	1.38	62
H 5044/2	1.37	64.5	H 5070	1.44	73
H 5049	1.45	64.5	H 5072	1.49	78.5
H 5053	1.52	81.5	H 5076	1.48	75.5

Average D_{30} 1.47
Average Mooney Value 72.5

The distribution of the measure of plasticity for these samples is approximately normal. Standard deviations in each group are:—

	Light	Medium	Dark
D_{30} Value ...	0.070	0.078	0.063
Mooney Value ...	4.99	5.28	6.02
No. of Degrees of Freedom	16	60	11

These values differ no more than is to be expected by chance. The means of the three classes are 1.44, 1.47 and 1.46 and an analysis of variance gives the following figures:—

	Degrees of Freedom	Mean Squares	
		D_{30} Value (x 10)	Mooney Value
Between Classes ...	2	0.4016	10.50
Within Classes ...	87	0.5589	28.42

It is well known that the plasticity of raw rubber changes with age (3), (9), and it is therefore possible that there might be more correlation between colour and plasticity after storage of the rubber than when it is freshly prepared. Some of the samples of the lightest and darkest sheet received during the first investigation of 18 months ago, together with a record of their original D_{30} values were not destroyed by the fire. A comparison has been made after storage for this period. The figures are given in Table V. No determinations with the Mooney plastometer were made when the rubbers were first examined as the instrument had not then been obtained.

TABLE V

Comparison of Plasticities of Light and Dark Sheet before and after Storage

Light-Coloured Sheet					Dark-Coloured Sheet				
Sample No.	D_{30}		Mooney Value		Sample No.	D_{30}		Mooney Value	
	Initial	After Storage 18 months	Initial	After Storage 18 months		Initial	After Storage 18 months	Initial	After Storage 18 months
H 4318	1.22	1.40	—	78	H 4289	1.21	1.47	—	78
H 4292	1.23	1.52	—	82	H 4288	1.21	—	—	76.5
H 4288	1.28	1.50	—	76	H 4295	1.25	1.48	—	88
H 4353	1.29	1.60	—	84.5	H 4381	1.27	—	—	85
H 4309	1.31	1.53	—	80	H 4355	1.29	1.52	—	86
H 4299	1.36	1.53	—	81	H 4323	1.29	1.54	—	80
H 4332	1.36	1.63	—	77	H 4346/1	1.30	1.59	—	93
H 4293/1	1.39	1.62	—	79	H 4306	1.40	1.69	—	96
H 4293/2	1.44	1.64	—	83	H 4335	1.41	1.57	—	89
Mean	1.32	1.54	—	80	Mean	1.29	1.55	—	86

The difference in D_{30} values for the light and dark groups are:—

Initial value ... ... 0.028 ± 0.034
After storage ... ... 0.01 ± 0.035

The increments in D_{30} during storage are:—

Light	...	...	...	0.221 ± 0.017
Dark	...	...	...	0.244 ± 0.015
Difference	...	...	...	0.023 ± 0.022

Both groups therefore show an increase in hardness with time at equal rates and the lighter samples have not hardened faster than the darker.

Martin (*loc. cit.*) has pointed out that the determination of the initial hardness of raw rubber can be useful for the purpose of evaluation only if it bears a relationship to the behaviour on mastication. He finds that a hard rubber usually requires more mastication than a soft one. He finds also that there is a significant correlation coefficient between initial hardness and amount of mastication required to reach a pre-determined plasticity, but does not consider that the amount of mastication required can be predicted from the hardness of raw rubber.

The development of a laboratory mastication-test by means of which raw rubber can be judged, is not easy in the absence of information correlating such small-scale experiments with actual behaviour in practice. In the factory it is easy to remove small quantities of rubber from the rolls at regular intervals during the mastication process, and so get the required information. This is not possible in the laboratory especially when the amount of material available is very small. The mastication-test which has been used in the present investigations is certainly comparative but it is not known to what extent it can be taken as a criterion of the probable behaviour on a large scale. In the procedure adopted, pieces of each sample, weighing 50 grammes, are passed through a laboratory mixing mill with 12 in. x 6 in. diameter rolls and roll speeds of 25 and 35 r.p.m., for different numbers of times. The nip between the rolls is set exactly at 40 thousandths of an inch. The rolls are water-cooled and at room temperature, approximately 28°C., at the beginning of each period of mastication. The number of grindings or passes given is usually 20, 40, 60, 80, and 100 for each sample. With the larger number of grindings the back roll tends to become slightly warm. It is a matter of a few degrees only, however, but before proceeding to the next mastication-trial both rolls are allowed to cool down to room temperature. The masticated rubber is then tested on the Mooney plastometer within a few hours of preparation and a mastication—plasticity curve plotted. From this curve the number of grindings required to give a Mooney-value of 50 is found, and confirmed by a further test on a sample which has received the predicted number of passes.

It is realised that the selection of this Mooney-figure is arbitrary, but it was selected as it is reported as that to which one big manufacturer in America, using the plastometer in works control, masticates his rubber for compounding. It is found that the results can be duplicated quite easily provided care is taken to observe that the experimental mastication conditions are strictly adhered to.

It is unnecessary to give many mastication figures to show that samples found to be hard in the unmasticated condition continue to remain harder on mastication than those found initially to be soft. Table VI gives the results of mastication-tests made on light, medium and dark sheets after storage for five months, and which were selected examples of hard and soft rubbers in each class when in the unmasticated condition.

TABLE VI

Mastication Values for Light, Medium and Dark Sheet

Colour of Sheet	Sample No.	Mooney Plasticity Value After Grinding						Number of Grindings to give Mooney value of 50
		0	20	40	60	80	100	
Light	H 5027	86	73.5	61	48.5	37	30	57
	H 5042	69.5	64	53	41.5	33.5	28.5	45
Medium	H 5024	89.5	82	64	51	40.5	32.5	61
	H 5007	70	62	53	43	33.5	28	46
Dark	H 5053	91	—	61.5	50.5	41	32.5	61
	H 5044/2	72	65.5	55	44.5	35	29	50

These results show that initially hard and soft samples in the dark class retain their differences after mastication as do those in the light-coloured class. Moreover, this mastication test does not show a light-coloured rubber which is initially hard or soft to break down on mastication less rapidly than its counterpart in the dark class. The initial Mooney-hardness values prior to mastication are all slightly higher than when originally tested. This is not unexpected, and is caused by the storage.

It is still possible that there might be correlation between colour and plasticity if the sheets were all prepared from the same crop of latex and treated alike up to the drying stage. In order

to investigate this a batch of sheet was prepared at the Institute from the same bulk of latex. All sheets were given similar preparation treatment and were identical in all respects up to the time of drying. They were then taken for drying to a number of selected local estates where it was known that the normal estate sheet varied in colour from estate to estate. These experimental

TABLE VII

Variation of Drying Treatment and Plasticity

Expt. No.	Where Dried	Temperature of Drying	Time of Drying (approx) Hours	Colour Details		Thickness inches	Mooney-Value	Number of grindings to give a Mooney-Value of 50
				Class	Order			
L 25/1	R.R.I. Hot-Air Cabinet	140°F.	91	Light	1	0.130-.140	77	49
L 25/2	R.R.I. Smoke House	130°-140°F.	63	Dark	13	„	65	45
L 25/3	Estate A	100°-130°F.	120	Medium	9	„	73	54
L 25/4	„ B	100°-130°F.	120	Medium	8	„	72	54
L 25/5	„ C	115°F.	168	Medium	10	„	75	54
L 25/6	„ D	120°F.	144	Dark	12	„	73	50
L 25/7	„ E	120°F.	163	Medium	7	„	76	51
L 25/8	„ F	120°F.	162	Medium	6	„	85.5	59
L 25/9	„ G	100°-150°F.	89	Medium	4	„	78	60
L 25/10	„ H	120°F.	160	Medium	5	„	87.5	67
L 25/11	„ I	110°-150°F.	90	Light	3	„	81.5	54
L 25/12	„ J	135°F.	204	Light	2	„	87	58
L 25/13	„ K	120°F.	214	Medium	11	„	72	54

sheets were put together with the estate sheet into the smoke-houses and their drying proceeded in a normal way. No attempt was made to ensure that they were given special attention, nor were the smoke-houses operated in any manner different from

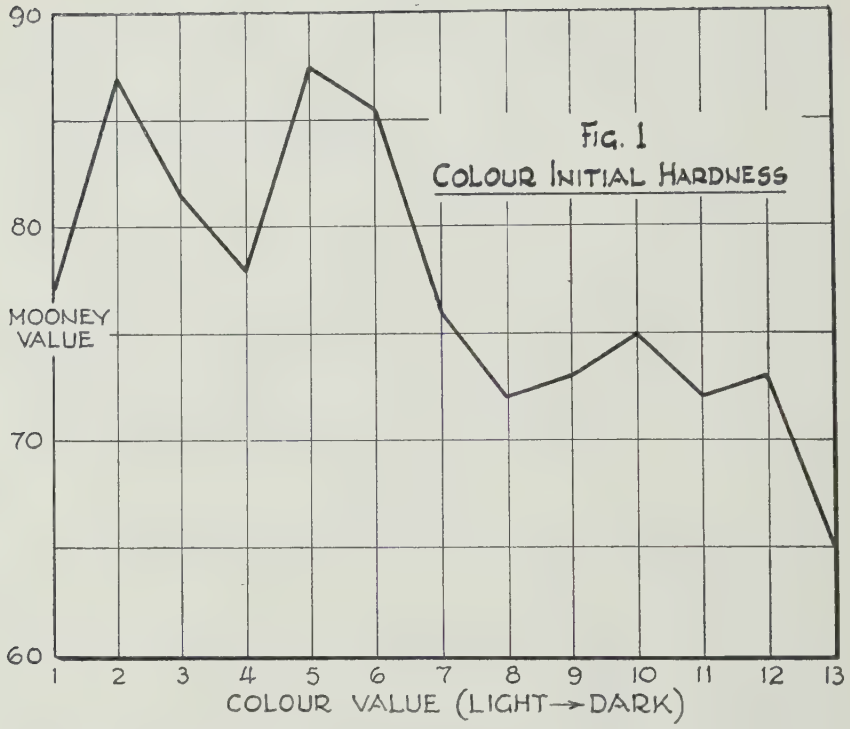

Fig. 1
COLOUR INITIAL HARDNESS

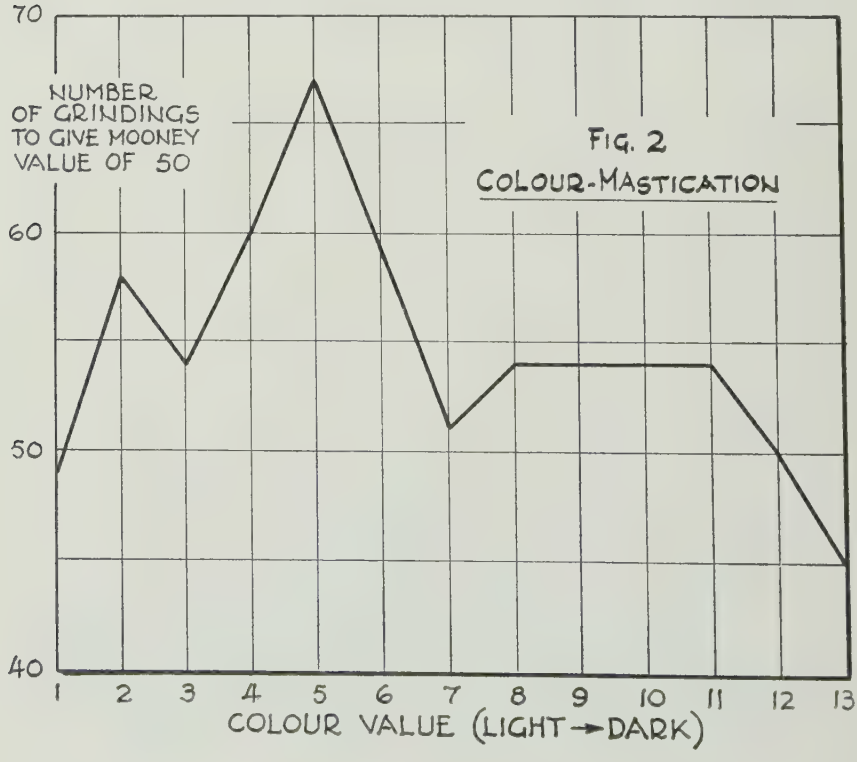

Fig. 2
COLOUR-MASTICATION

the normal. When the sheets were dry, they exhibited an excellent and complete range of colour. They varied with an almost uniform gradation from the light golden of the hot-air-dried to the very dark, almost black colour of a sheet which is heavily oversmoked. The two extremes of colour were obtained in drying-houses at the Institute and the dark sheet would undoubtedly have been penalised as badly oversmoked if offered in the open market. Of the sheets dried in the estate smoke-houses, two would have been considered to be light and one dark-coloured, whilst the others would have been classified as of a medium shade.

The plasticity figures given by these samples tested on the Mooney instrument three months after preparation are given in Table VII together with their colour and drying details.

The samples were then given a mastication-test similar to that described earlier. The number of grindings required to produce a Mooney-value of 50 is given in the last column of Table VII.

The figures for Mooney-plasticity on the unmasticated samples and those for the number of grindings required to give the value of 50 have been plotted against the colour values, Figs. I and II, and are of some interest. The results for the rubbers having colour-values from 5 to 13 show a correlation between colour and plasticity. In the colour zone 1 to 5 however no such relationship is obvious; it is somewhat surprising to find that the hot-air-dried sheet which has had no smoke at all, is so soft, and that the smoked sheets having little colour (2 and 3) are softer than those with more (4 and 5) as judged by the mastication-test. Reference to the drying conditions given in Table VI shows however that the former sheets were dried at higher temperatures. It is also the fact that Estates G and I have drying-houses of a patented type which use for the last part of the drying process a hot-air-heated chamber elevated to higher temperatures than are usual in estate smoke-houses. Fitting to the data given in Table VIII a linear equation of the form

$$q = k + b_1 \times + b_2 t.$$

$$\text{and } m = k_1 + b_1' \times + b_2' t.$$

where q = Mooney grinding number

m = Mooney Value

x = Colour measured in arbitrary units defined by the order of the samples in colour value

t = temperature in degrees F

gives regression coefficients as follows:—

Regression of	Coefficient	Standard Error	P*
Grinding Number on Colour ...	—1.080	0.354	$< 0.02 > 0.01$
Grinding Number on temperature ...	—0.440	0.163	< 0.05
Mooney Value on Colour ...	—1.545	0.373	< 0.01
Mooney Value on temperature ...	—0.262	0.172	> 0.1

* P = The probability that a coefficient larger than that observed might occur by chance.

The data therefore suggest that within a single sample of latex the plasticity of the sheet prepared from it might be affected both by smoking and by temperature. There is less than one chance in 50 that the correlation shown between colour and the number of grindings required to reach the Mooney-value of 50 may be due to chance, and about one in 40 that the correlation of temperature and grinding may have occurred fortuitously. No significant correlation of Mooney-value with temperature is shown but it is likely that with more extensive data it might be shown to be similarly correlated. Extending the above equation to include time-of-drying accounts for no more of the total variance, the regression coefficient for grinding number on time-of-drying being only $+ 0.019 \pm 0.031$. It is thus demonstrated that colour may be associated with plasticity if other conditions are constant. But since plasticity is also affected by many other factors there can be no generalisation that light rubber tends to be hard. Other conditions are not in general constant and may result in complete negation of this association as is illustrated by colour grades 1—3 in these data—an effect for which temperature-of-drying appears to be responsible.

Discussion

The experiments of Young and Ruch (*loc. cit.*) were carried out on a factory-scale and proved conclusively that the light sheet used by them was harder than the dark sheet. How far could this conclusion have been predicted by laboratory plasticity and mastication tests using small quantities of rubber?

The literature on the subject of plasticity does not appear to record sufficient evidence concerning the correlation of conclusions drawn from an examination on a small scale in the laboratory and actual works' experience. It is suggested that such information would be of benefit. It is appreciated that most manufacturers have standard routine works' processes to which they adhere as far as is possible, and also that a laboratory control is usual as a check on this routine. In most cases however, this control has been developed to suit the process concerned and will differ among different manufacturers.

There are several instruments for measuring the plasticity of rubber all of which are well known and need no description here. Further it can be said to be true that when a raw rubber is tested on any of these instruments it is very unlikely that one will reverse the findings of another. How will each instrument react when asked to classify samples in the laboratory for the purpose of giving mastication advice in the mill room? Will they all give the same answer? It would surely be of benefit to the users of these instruments if there were some standard form of test which could be applied to a small quantity of the raw rubber from which predictions on a large scale could be made.

From the production research standpoint it is undesirable that tests should require large quantities of rubber for evaluation, or in other words a semi-works' trial. Martin discussing his test mentions that it is a measure of the mastication required to reach the average plasticity of samples supplied by six manufacturers. He comments that the difference between their requirements is enormous; some apparently prefer rubber forty times as plastic as others. It is certainly desirable that whatever attempts are made to translate laboratory tests into terms of works' practice they should be based on an actual mastication-test. It is again preferable that the results should be reported in terms of the amount of mastication required to produce a certain plasticity rather than in terms of the plasticity of the sample after a fixed mastication. This is what has been done in the present work, but would these findings agree with those of a manufacturer in actual works' practice?

In order to obtain some information on the accuracy of the opinions which have been formed as a result of laboratory work here on the light and dark sheet question, a consignment of light and dark rubber was sent to the Crude Rubber Committee of the Rubber Division of the American Chemical Society for the opinion of its members. The rubbers were prepared from the same bulk of latex and dried in two estate smoke-houses normally producing sheet which is light and dark respectively. The colour

difference was not as great as was expected but it was nevertheless definite. The American report was that no difference could be found in plasticity between the two rubbers. It was also stated that no evidence was available in America in support of the opinion held in Europe concerning the differences in plasticity with colour.

The problem of variation in plasticity of raw rubber is undoubtedly a real one and if the producing organisations are able to do anything to aid the manufacturer by eliminating it they are most anxious to do so; the present work was prompted by that desire.

From the laboratory experiments described it would appear that the manufacturer buying sheet in the open market may be as likely to obtain a hard rubber by a random choice among dark as he is among light sheet. It also appears as if considerable variation in plasticity can occur as a result of the treatment to which the wet sheet is subjected by the producer during the final stages of preparation.

It has been noticed in this laboratory over a long period of time that hot-air-dried sheet is always harder than the smoked sheet prepared from the same latex given similar drying temperatures. The drying conditions at the Institute, however, are such that a very dark-coloured sheet results on smoking. Martin (2) states that hot-air-dried usually requires 15 per cent more mastication than smoked sheet. The results given in Table VI and Figs. I and II are not entirely in agreement with this and it is suggested that perhaps the conditions under which plasticity is determined may be responsible.

Before making any recommendations to the producer, however, it is felt that more information concerning the correlation of laboratory and factory experience is required, particularly in view of the fact that the results of the present work do not entirely support the generalisation made by some manufacturers on the matter of colour and plasticity.

Summary

Experiments on the plasticity of sheet rubber of various depths of colour are described from which it is concluded that the generalisation cannot be made that depth of colour is correlated with plasticity. Some evidence is given, however, to show that under special circumstances there is an apparent correlation. The anomaly is discussed and a plea put forward for further work on the correlation of laboratory-plasticity experiments and factory practice.

Acknowledgment

The writer wishes to acknowledge the assistance given by his colleague Mr. Fairfield Smith in the statistical examination of the data given in this paper.

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THE CONSTITUENTS OF HEVEA LATEX

PART V

THE ISOLATION OF THE CONSTITUENTS

BY

K. C. Roberts

(Continued use of the method described in Part I of this Series (J.R.R.I.M., 1936, **7,** *46) for the isolation of the constituents of Hevea latex has led to the introduction of a number of improvements. The revised procedure is described in the following paper, which is reprinted from the "Journal of the Chemical Society" (1938, 215).*

Summary.

Finality of outlook has not yet been reached on many aspects of rubber science. Opposing views are held on the most fundamental phenomena, such as the elasticity of rubber and its behaviour on exposure to air and light, and even its elementary composition and its molecular weight are still subjects of discussion. Until now no single comprehensive process has existed for the separation of natural rubber into its constituents, and it was felt that the development of such a process might throw light on some at least of the debated points.

The material hitherto regarded as the rubber hydrocarbon consists of two constituents—caoutchene and caoutchol (see following paper)—each of which lacks certain fundamental properties of natural rubber. Other points established are (*a*) the existence of two new minor non-hydrocarbon constituents, (*b*) the separation of the phosphatic material into two contrasted fractions, and (*c*) the failure to separate completely the major nitrogenous constituent and the rubber hydrocarbon.

Quantitative analyses based on the process are proving of value in approaching the problems of the variability of latex and of rubber, the effect of preservation on latex, and latex metabolism.

It is generally accepted that the solid matter which constitutes 30—50% of the latex of *Hevea brasiliensis* (the source of almost the whole of the raw rubber of commerce) consists essentially of the rubber hydrocarbon (~90%) together with small and varying amounts of mineral phosphates, sugars, quebrachitol (*l*-methylinositol), fatty acids, sterols, and nitrogenous matter including protein. Raw rubber and the various concentrated latices of commerce contain all these constituents, but owing to their modes of preparation they contain in general a more or less reduced amount of water-soluble matter, *viz.*, phosphates, sugars, quebrachitol, and nitrogenous matter.

Many detailed investigations of individual constituents have been reported, but there is in general use for the examination of latex or of rubber no method which involves the isolation of the constituents in the forms in which they occur in the raw product. In this respect no advance has been made on the work of Faraday, who (*Quart. J. Sci.*, 1826, **21,** 19) reported the quantitative isolation of the constituents of a rubber-bearing latex from Mexico.

Present practice is to indicate the composition of rubber in terms of its content of "resin" (acetone extract), "sugars" (reducing power of water extract), ash, "protein" (nitrogen content × 6.25), and "hydrocarbon" (the elastic residue). This has led to preconceptions on the part of many workers in this field. The nature of the substances responsible for the reducing power of the water extract of rubber is not yet well established, and attempts to isolate a protein have met with only partial success. Further, the current view that the essential rubber "substance"—the above elastic residue—is a hydrocarbon, is not well founded. The precise analytical data of Midgley, Henne, Shepard, and Renoll (*J. Amer. Chem. Soc.*, 1935, **57,** 2318) have shown that the elastic constituent of rubber contains a small but definite amount of hydroxylic oxygen.

In developing the present method for the isolation of the constituents, a departure has been made from current practice. Whereas it is customary to remove non-hydrocarbon material from rubber by extraction processes, the primary separation is now effected by treating a solution of rubber in such a way that the purely organic non-hydrocarbon constituents are retained in solution on removal of the hydrocarbon and the mineral-containing constituents by precipitation. To this end, the rubber is dispersed in an approved mixture of carbon tetrachloride and acetone, and the dispersion is treated with a further quantity of acetone (see scheme).

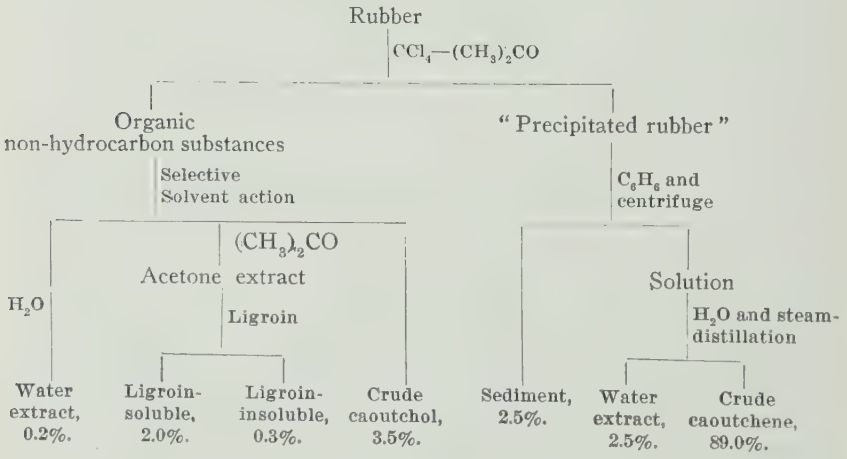
There is a two-fold reason for the use of the mixed dispersing agent: first, it expedites the notoriously slow process of dispersion of rubber by taking advantage of the fact that addition of acetone to such dispersions markedly reduces their viscosity; secondly, it exploits a possibility which does not appear to have been appreciated hitherto, that this reduction of viscosity may be due to a breakdown of the micellar structure of dispersed rubber in presence of acetone. If such a breakdown takes place, the rubber in the mixed dispersing agent will approach more closely to a true unimolecular state than in a simple solvent.

The principle employed in the further treatment of both the organic non-hydrocarbon material and the "precipitated rubber" (the mixture of hydrocarbon and mineral-containing constituents will be thus referred to) is to submit each to treatment by

physical, as opposed to chemical, means until the ultimate constituents of the raw material are obtained.

For this purpose the organic non-hydrocarbon material is treated by selective solvent action (see scheme). First, by means of water, a small amount of a hitherto undetected organic material containing nitrogen is removed. The acetone-soluble portion of the remainder is further separable into ligroin-soluble and ligroin-insoluble portions. Preliminary work shows that the former consists essentially of a group of substances hitherto isolated from the "acetone extract" of rubber, which has been examined in some detail by Bruson, Sebrell, and Vogt (*Ind. Eng. Chem.*, 1927, **19,** 1187) and by Whitby, Dolid, and Yorston (J., 1926, 1448). The ligroin-insoluble material, on the other hand, has not previously been detected. The portion of the organic non-hydrocarbon matter remaining after these extractions has novel characteristics. It is an elastic substance which comprises 2—5% of the solid matter of raw rubber, but differs from rubber in that it readily dissolves in ether to give clear solutions having a very low viscosity. For reasons which appear in the ensuing paper, this new substance has been named "crude caoutchol."

The above non-hydrocarbon constituents all burn without ash. Further, they contain only very small amounts of nitrogen and quebrachitol and give no evidence of the presence of the free reducing sugars frequently stated to be present in rubber. The inference is that practically the whole of the quebrachitol, mineral and nitrogenous matter, and sugars of the original rubber is retained by the "precipitated rubber."



Scheme illustrating the separation of the constituents of *Hevea* rubber.

The constituents occupying the lowest line appear to be the ultimate ones separable by usual physical processes. The figures represent typical amounts of each, and are expressed as percentages of the total solid matter of latex.

The effect of the removal of the new constituent caoutchol is immediately seen in the properties of the "precipitated rubber," which is characterised by its lack of tensile strength and by the remarkably low viscosity of its solutions in the usual rubber solvents. These properties have been utilised for the removal of further non-hydrocarbon materials (see scheme). Thus the viscosity of a 3—4% solution of the "precipitated rubber" in benzene is sufficiently low for undissolved non-hydrocarbon material to be removed from it by centrifugal action. Further, the non-hydrocarbon material retained by the mobile solution after this treatment may be quantitatively removed in water by the procedure described below. The sediment and the water-extractable material so obtained together comprise the substances hitherto known as the "serum solids" of latex or as the water-soluble matter of rubber, but this is the first occasion on which a separation of this matter into two well-defined fractions has been effected.

The non-hygroscopic, water-soluble sediment and the hygroscopic water extract together contain only about one-fourth of the total nitrogen of rubber (unpublished results), the major portion of which therefore remains associated with the residual rubber. The point is now emphasised that all attempts to separate the latter quantitatively into a nitrogenous constituent and a pure hydrocarbon have completely failed. The nature of the retained nitrogenous matter remains obscure. It is proposed to call the nitrogen-containing residue "crude caoutchene," and to reserve the name "caoutchene" for the pure hydrocarbon. Crude caoutchene is remarkable in that it is notably deficient in toughness and elasticity, properties hitherto regarded as fundamental attributes of the essential rubber substance.

With a view to determining the effect of a variety of factors on the composition of latex and of rubber, the separation of rubber into the above seven constituents has been placed on a quantitative basis. The table summarises the results of typical analyses of the total solid matter of latex and of a high-grade crêpe rubber.

Per cent. of total solids.

Components of primary separation.	Constituent.	Item No.	I, Latex.	II, Crêpe.
Organic non-hydrocarbon material	Water extract	1	0.28	0.03
	Acetone extract:			
	(i) Ligroin-insol.	2	0.27	0.14
	(ii) Ligroin-sol.	3	2.37	1.75
	Crude caoutchol	4	4.71	3.23
"Precipitated rubber"	Sediment	5	2.75	0.01
	Water extract	6	2.12	0.24
	Crude caoutchene	7	87.02	94.04
	Total	—	99.52	99.44

The newly discovered material caoutchol is seen to be the major non-hydrocarbon constituent of rubber.

The percentage of non-hydrocarbon matter for the above typical specimen of *Hevea* latex (col. I) is higher than that usually reported in spite of the absence of the usual item "protein," which is now included under crude caoutchene. Comparison of cols. I and II shows that the water-soluble matter (items 1, 5, and 6) is largely removed in the preparation of crêpe rubber. The differences between the other pairs of figures are not unusual for a biological fluid.

Experimental

The finely divided, dried sample of rubber (30 g.) is added to a mixture of carbon tetrachloride (700 c.c.) and acetone (450 c.c.). The mixture is stirred intermittently until a homogeneous, opalescent and relatively mobile dispersion results, usually in 2—4 hours, but the mixture is kept in subdued light for 24 hours to allow time for the break-down of the micellar structure. A further 450 c.c. of acetone are then added while the mixture is agitated. The crude caoutchene together with phosphatic matter is quantitatively precipitated in fine white flakes, which slowly coalesce. After the mixture has been kept for 24 hours in subdued light, the supernatant, clear, pale yellow solution is decanted, and the "precipitated rubber" is washed first with 50 c.c. of a mixture of carbon tetrachloride (7 vols.) and acetone (9 vols.) and finally with acetone (50 c.c.). The combined solution and washings are distilled to small bulk and the remaining solvent is removed on a water-bath. The residue consists of the organic non-hydrocarbon constituents.

Treatment of the Organic Non-hydrocarbon Constituents.—Water extraction. The oily, dark-coloured material is extracted three or four times with small quantities of water, and the resulting pale yellow, slightly opalescent extract is dried on the water-bath. The product (approximately 0.2% of the total solid matter of latex) frequently includes as impurity a small amount of quebrachitol, which may be removed by treating the product with ethyl alcohol, in which quebrachitol is insoluble. The purified material is a viscous yellow oil which slowly deposits crystals.

Acetone extraction. The material remaining after the water extraction is stirred vigorously several times with warm acetone until all acetone-soluble material has been dissolved. Acetone is removed from the extract on the water-bath and the residue is resolved with ligroin.

The ligroin solution, dried to constant weight, yields a very viscous, dark red oil (1.5—2.5% of the rubber), which comprises

the bulk of the acetone-soluble material. It slowly deposits crystals, and preliminary investigation of its hydrolytic products shows it to consist essentially of a complex of aliphatic acids, complex alcoholic substances, and a glucoside, together with small amounts of unidentified terpenic material. A small amount of a water-soluble, odorous, sulphur-containing substance is also present.

The ligroin-insoluble matter, constituting approximately 0.3% of the rubber, appears to consist of unsaturated higher aliphatic acids combined with an unidentified water-soluble substance.

The acetone-insoluble residue, dried on the water-bath, varies somewhat in texture from sample to sample, but is in general a transparent, brown, plastic solid possessing a high degree of elasticity and constituting 2—5% of rubber. It contains a small amount of sulphur. It dissolves rapidly in rubber solvents and in ether, giving very mobile and almost clear solutions, but is insoluble in alcohol. It is a crude form of the substance caoutchol described in the ensuing paper.

Treatment of the "Precipitated Rubber."—The washed "precipitated rubber" (cf. above) is rolled to a thin sheet on a mill and allowed to dry by evaporation in subdued light at room temperature (24 hours). A solution of the material (10 g.) in benzene (300 c.c.) is kept in a centrifuge for 30 minutes at 2000 r.p.m., and the supernatant, clear yellow solution is then decanted. The sediment, representing approximately 2.5% of the total solid matter of latex, is carefully washed with small quantities of benzene and may be weighed. It is a white, non-hygroscopic powder which is essentially soluble in water, although it is liable to be contaminated with traces of rubber and also with any fine dirt (earth, bark scrap, etc.) which was present in the original specimen. Latex is as a matter of routine purified by sieving, but the nature of the liquid permits of the removal only of coarser impurities by this method.

The benzene solution, together with the washings, is treated with water (1000 c.c.) in a 2-l. flask. The mixture, shaken to an emulsion, is distilled with steam. A clear liquid and a spongy white mass remain in the flask. After decantation of the liquid, the residue is rinsed several times with water, and the liquid expressible from it is added to the main bulk, which, after being concentrated on a hot-plate, is finally dried to constant weight on the water-bath. The pleasantly odorous, clear brown, vitreous product, representing approximately 2.5% of the total solid matter of latex, is highly hygroscopic and forms large crystalline plates in contact with moist air.

The washed spongy mass is passed through a rolling mill before being dried in a vacuum over sulphuric acid. The tacky,

very feebly elastic product retains the bulk of the nitrogen of the original material [Found: N (original rubber), 0.55%; N (residue), 0.42%]. It constitutes about 89% of the total solid matter of latex. A description of the material, which is named crude caoutchene, and an account of unavailing attempts to remove further non-hydrocarbon matter from it will be found in the ensuing paper.

Notes.—(1) Benzene may take the place of carbon tetrachloride in the initial stage of the process, but the acetone, owing to its highly specific action, is not replaceable by other common precipitants for rubber, such as alcohol. When benzene is used, the above proportions of solvent and precipitant require modification.

(2) The process has been carefully examined, particularly with respect to the possibility of oxidative or other changes in the constituents. No evidence of such changes has been obtained.

(3) The process lends itself to the analysis of any of the forms of raw rubber commonly met with, *viz.*, crêpe, smoked sheet, crumb, powder, or liquid latex. The last is conveniently prepared for analysis by spreading it in a thin film on plate-glass and drying it at 50—55° in a dark chamber. Analyses of latices and rubbers, the preparation of which has involved special chemical or other treatment, naturally present additional features. These will be reported elsewhere.

(4) Carbon tetrachloride is readily recoverable from the process by treating the distilled carbon tetrachloride-acetone mixture twice with large volumes of water.

Kuala Lumpur

27th April, 1938

THE CONSTITUENTS OF HEVEA LATEX

PART VI

CAOUTCHENE AND CAOUTCHOL AND THE INTERMOLECULAR STRUCTURE OF RUBBER

BY

K. C. ROBERTS

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Summary

The two components of the material hitherto regarded as the rubber "substance" (cf. preceding paper) are described.

Crude caoutchene, the major component, comprises 95—98% of this material, and consists essentially of a typical polyterpene, caoutchene. It is tacky and only feebly elastic. With it is very intimately associated a small amount of unidentified nitrogenous matter. Molecular-weight evidence indicates that *caoutchene* is an octaterpene, $C_{80}H_{128}$, the molecules of which are considerably associated at room temperature.

Crude caoutchol, constituting 2—5% of the former rubber "substance," consists of an alcohol, *caoutchol* (~97%), in combination with complex unidentified acidic material (2—3%) which contains sulphur. The evidence suggests that caoutchol is a dihydrate, $C_{80}H_{130}(OH)_2$, of caoutchene. The alcohol freshly purified by hydrolysis is a tough non-tacky substance which resembles rubber in being highly elastic, but differs from it in dissolving freely in ether to clear mobile solutions. The molecules of the freshly prepared substance are appreciably associated at room temperature.

The influence of caoutchol on the physical properties of plantation rubber is discussed. Evidence from viscosity measurements and other considerations in support of a two-phase intermolecular theory is adduced.

Two views of the nature of purified rubber are widely current—one, that it is composed of very large, open-chain hydrocarbon molecules having a molecular weight of the order of 100,000 (Staudinger and collaborators, 1920—1937. For a summary, see Staudinger, *Trans. Inst. Rub. Ind.*, 1934, **10,** 263); the other, that it consists of micellar aggregates of relatively small hydrocarbon molecules having a molecular weight of 1100—1600 (Pummerer, *Ber.*, 1927, **60,** 2167; 1928, **61,** 1591; 1929, **62,** 2628). The first is based primarily on consideration of the viscosity of rubber solutions, and the second on cryoscopic molecular-weight determinations of rubber in camphor and similar solvents. Neither view provides a basis for a convincing explanation of the remarkable degree of elasticity of raw rubber. Midgley, Henne, Shepard, and Renoll (*J. Amer. Chem. Soc.*, 1935, **57,** 2318) on the basis of analytical evidence have advanced the further view that the rubber

molecule contains a hydroxyl group and has a minimum molecular weight of 40,000.

New light is thrown on the subject by the separation of the supposed rubber "substance" into two constituents (see preceding paper), crude caoutchene and crude caoutchol (95—98% and 5—2% respectively of the former rubber "substance").

Caoutchene.—Crude caoutchene, the tacky, feebly elastic material which constitutes 87—91% of the total solid matter of *Hevea* latex, consists preponderantly of carbon and hydrogen (~99%) together with small amounts of nitrogen, sulphur, and oxygen (~1%). Attempts to remove nitrogenous matter have proved unavailing. Midgley, Henne, and Renoll (*J. Amer. Chem. Soc.*, 1931, **53,** 2733) have, however, isolated from rubber by fractional precipitation at the critical temperature a small amount of nitrogen-free material, and it is therefore inadmissible to conclude that nitrogen is a component of the rubber molecule. It is accordingly assumed that crude caoutchene consists of a hydrocarbon in intimate association with an unidentified nitrogenous constituent. Analytical and molecular-weight evidence indicates that the hydrocarbon is an octaterpene, $C_{80}H_{128}$, to be called *caoutchene*. It is noteworthy that the nitrogen content of crude caoutchene from numerous specimens of fresh latex has remained practically constant (0.42 ± 0.05%) over a period of months. The nitrogen content of crude caoutchene from other sources is discussed in the experimental section. Two points have been established concerning the nature of this nitrogenous matter: (1) the nitrogen is, at least in part, of amide type; (2) the relative amounts of nitrogen, oxygen, and sulphur are similar to those found in typical proteins.

Crude caoutchene is not a pure substance, but it may readily be shown that, since the amount of nitrogenous constituent present is very small, variation of its carbon/hydrogen ratio within quite wide limits will not cause a material divergence of the carbon/hydrogen ratio found for *crude* caoutchene from that of *pure* caoutchene. Any divergence will be inappreciable if the nitrogenous constituent is protein, the average carbon/hydrogen ratio for which (10/15.7) is very close to that of the terpenes (10/16). In other words, the carbon and hydrogen values found for crude caoutchene may fairly be taken as representing those of the hydrocarbon constituent. Thus from typical findings of C, 87.1; H, 11.8% for crude caoutchene, C, 88.1; H, 11.9% may be calculated for the hydrocarbon constituent, figures which are in good agreement with those required for $(C_5H_8)_x$, *viz.*, C, 88.2; H, 11.8%. In this connection attention is drawn to the remarkably close physical resemblance between caoutchene as now

obtained and the synthetic polyterpene, polymyrcene, of undetermined molecular weight, which is also a tacky mass (Harries, *Ber.*, 1902, **35,** 3264).

The molecular weight of crude caoutchene in melting camphor lies between 990 and 1170 ($C_{80}H_{128}$ requires 1088). Objections to the Rast method on the grounds that the high temperature involves decomposition of the rubber have been refuted elsewhere (Pummerer, Andriessen, and Gündel, *Ber.*, 1929, **62,** 2628), but it may also be mentioned that repeated cooling and remelting of a camphor solution of crude caoutchene produces no change in the melting point. Further, the molecular weight now observed is much lower than that of 3400 reported by Staudinger and Bondy (*Annalen*, 1929, **468,** 1) for rubber heated in solution at a considerably higher temperature, *viz.*, 206°. Crude caoutchene undoubtedly exists in a considerably associated state at room temperature. The viscosity of its solutions, though of a different order from that of identical solutions of raw rubber (see Table, p. 318), is nevertheless considerable, and it has proved impossible to determine its molecular weight in benzene. Carothers and collaborators have shown (*J. Amer. Chem. Soc.*, 1930, **52,** 5279) that the intermolecular cohesive forces in paraffin hydrocarbons having a molecular weight of about 1000 approach the strength of the intermolecular C-C link. It is therefore to be expected that caoutchene should exist in a very strongly associated state.

Caoutchol.—Crude caoutchol is composed of an alcohol *caoutchol* (97—98%) in combination with a small amount of a complex mixture of unidentified aliphatic acids (2—3%). In view of the experimental evidence, and because of the close relationship of caoutchol to caoutchene, the alcohol is considered to be the octaterpene dihydrate $C_{80}H_{130}(OH)_2$. It is nitrogen-free, but contains in addition to the above acids a variable and very small amount of an acidic sulphur-containing substance which has not yet been identified. Pure caoutchol prepared by hydrolysis of the crude product exists in the unimolecular form in melting camphor. Viscosity and benzene freezing-point observations indicate a considerable degree of association of its molecules in solution at room temperature.

Caoutchol contains 2.8% by weight of oxygen. Raw rubber, containing 2—5% of caoutchol, may therefore, after being freed from its other non-hydrocarbon constituents, contain as little as 0.05% of oxygen. This figure is in excellent agreement with that of 0.04—0.05% arrived at by Midgley, Henne, Shepard, and Renoll (*loc. cit.*) from a consideration of the results of analyses of rubber itself. This amount is so small as to evade detection by ordinary analytical technique. In any case, the prevailing belief that the

rubber hydrocarbon is readily oxidised under atmospheric conditions has led the majority of investigators to regard oxygen found in purified rubber as having been adventitiously acquired.

The basis of the view of the physical nature of rubber now to be discussed is the remarkable degree of elasticity displayed by caoutchol, which, when freshly prepared, is as highly extensible as raw rubber itself. In view of its relatively low molecular weight (1124), this phenomenon must apparently be attributed to association of the molecules of the substance by means of their hydroxyl groups. A substance composed of long molecules associated in this way would inevitably form a complex network which might be expected to show the observed characteristics. It has been mentioned above that caoutchene, the major constituent of rubber, is relatively feebly elastic, exhibiting rather the highly viscous nature to be anticipated in a polyterpene. It is therefore suggested that the elasticity of raw rubber is essentially that of the minor constituent caoutchol, which in virtue of its own state of association and of its power of forming further associated links between its hydroxyl groups and the residual affinity of the caoutchene molecules, acts as a binding material which imparts its own elasticity to the entire mass.

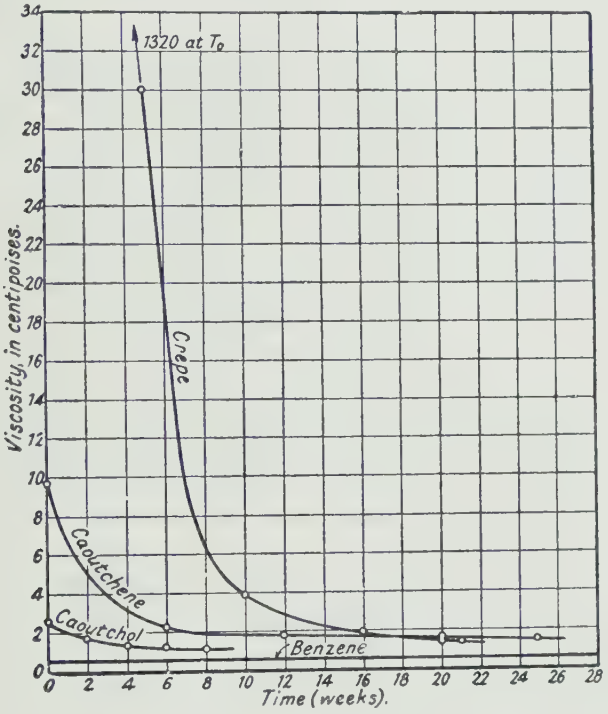
A two-phase theory of the nature of rubber, similar in outline to the above, has been put forward by Fessenden (*J. Franklin Inst.*, 1896, **142,** 187; cf. Whitby, "Plantation Rubber and the Testing of Rubber," p. 257) from theoretical considerations, and a similar view of the structure of muscle has been advanced by Meyer and Picken (*Proc. Roy. Soc.*, 1937, *B*, **124,** 29).

The elasticity of certain synthetic rubber substitutes may not be explained on the above basis, and is presumably due to the enormously high degree of polymerisation of their thread-like molecules. These would, by becoming entangled, impart to the material a matted structure which would resist deformation.

The two-phase intermolecular theory receives strong support from the following considerations. The viscosity measurements of contrasted specimens of rubber in freshly prepared solutions at the same concentration fall into two groups, one having viscosities of at least 1000 centipoises, the other of at most 100 centipoises.

Specimen.	Viscosity of 3.8% soln. in benzene.
Latex total solids	6300 centipoises
„ „ „ acetone-extracted ...	4100 „
Pale crêpe rubber	1320 „
Pale crêpe acetone-extracted	1040 „
"Precipitated rubber" (cf. Part I) ...	15—100 „
Crude caoutchene	10—30 „
Caoutchol	2—4 „

All the specimens which contain caoutchol are in the former group, and the latter consists of those from which caoutchol has been removed. The low figure for caoutchol is noteworthy.



Changes of Viscosity of 3.8% Solutions in Benzene of Crêpe Rubber, Caoutchene and Caoutchol in Diffuse Daylight.

Further, the initial very high viscosity of a solution of crêpe rubber when kept in a closed vessel in diffuse daylight rapidly approaches a low value similar to that reached by caoutchol-free rubber solutions and by caoutchol solutions under the same conditions (Figure). When kept in the dark, however, solutions of raw rubber retain their intermolecular structure: during 20 weeks, the viscosity of a 3.8% benzene solution of crêpe rubber fell only from 1320 to 920 centipoises. Staudinger considers (*Trans. Inst. Rubber Ind.*, 1934, **10,** 276) that the fall in viscosity in light is due to disruption of the rubber molecule by traces of atmospheric oxygen, but because of the magnitude of the effect now recorded and of the cryoscopic evidence discussed above, the writer prefers to regard it as due to a lowering of the degree of association. Further, crêpe rubber contains the naturally occurring non-hydrocarbon constituents which are well known to protect the hydrocarbon from oxidation. Evidence in favour of the disaggregation of rubber without oxidation has been advanced by

others (for a summary, see Fisher, *Chem. Reviews*, 1930, **7,** 70). Additional support for this view is provided by the observation that crude caoutchene may be liquefied under conditions which preclude either oxidation or dissociation of its molecule (see Experimental).

The vital rôle of caoutchol in imparting elasticity to plantation rubber is further indicated by the parallel behaviour of caoutchol and of rubber under the action of heat. Caoutchol, which is tough at room temperature, is soft and plastic at 50—60° and is a viscous fluid at 100°. Correspondingly, rubber, which retains considerable elasticity at 45°, is preponderantly plastic at 70° (Hauser, Rosbaud, and Schmidt, *Kautschuk*, 1928, **4,** 12; Memmler, "Handbuch der Kautschukwissenschaft," p. 655). Further, the *X*-ray diffraction pattern produced by stretched rubber in virtue of its elasticity vanishes under diverse conditions between 40° and 90° (von Susich, *Naturwiss.*, 1930, **18,** 915; Pummerer and von Susich, *Kautschuk*, 1931, **7,** 117). It is suggested that this temperature range is determined by the fact that caoutchol loses its elasticity within the same range. The diffraction of *X*-rays by caoutchene and caoutchol is now being investigated in this laboratory.

The action of caoutchol on caoutchene is apparently highly specific, but other substances also have a marked effect on the physical nature of caoutchene. Thus the "precipitated rubber" (preceding paper), which consists of crude caoutchene together with the bulk of the water-soluble matter of latex or rubber, though it resembles crude caoutchene in being readily soluble and only slightly elastic, is tougher and less self-adhesive. It has also been observed that a film consisting of the total solid matter of latex is mechanically much stronger than raw plantation rubber, from which practically all water-soluble matter has been removed. Crude caoutchene in the wet state is also tough and non-tacky. The presence of certain non-elastic materials therefore appears to impart toughness to caoutchene, without, however, appreciably increasing its elasticity. One may compare the analogous action of small amounts of divinylbenzene in changing the character of polystyrene (Staudinger, *Ber.*, 1935, **68,** 1618).

The highly specific rôle of acetone in permitting the separation of caoutchol and caoutchene may be explained on the above view of the nature of rubber. It is suggested that the presence of a certain limited amount of acetone in a rubber dispersion causes a redistribution of co-ordinate links, links between the carbonyl-oxygen of acetone and the hydroxyl group of caoutchol being formed preferentially to those between molecules of caoutchol and caoutchene which normally persist in a dispersion. In this way

the usual intermolecular structure of a dispersion is destroyed and the viscosity undergoes the observed reduction. In other words, the caoutchol is in a sense "solvated" by the acetone, and it ceases to maintain the intermolecular structure of the dispersed rubber, which is thus free to dissolve. Carefully regulated addition of more acetone quantitatively precipitates caoutchene (and the attendant insoluble inorganic matter) while the "solvated" caoutchol remains dissolved. In this way the resolution of the essential rubber "substance," which has so long eluded investigators, is effected. Still further addition of acetone will reduce the concentration of carbon tetrachloride (or other rubber-dispersing medium) to the point at which it can no longer hold caoutchol in solution, and the caoutchol, somewhat more soluble than caoutchene, will then be precipitated.

Experimental

Crude Caoutchene.—Several of the physical characteristics of the material described by this name in the preceding paper have been mentioned in the foregoing. The material varies considerably in texture according to the previous history of the specimen, that obtained from fresh latex being more tacky (less highly associated) than that from plantation rubber. Additional data are: (*a*) Crude caoutchene has no definite melting point. When maintained at 100° under reduced pressure for 1—2 hours, it changes to a pale brown highly viscous liquid without increase in weight. When heated at 100° in air, it slowly oxidises (Found: Increase in weight after 24 and 48 hours at 100° in air, 0.32 and 3.30% respectively). This reaction will be discussed more fully in a later communication. (*b*) It is extensible without rupture by only 100—200% and shows very poor elastic recovery. It has proved impracticable (see next paragraph) to purify the material further, and it has therefore been brought to analysis in the crude state [Found, *e.g.*: C, 87.0; H, 11.8; N, 0.5; S, 0.1; O (by diff.), 0.6; *M* (Rast), 1050, 1109 ± 60. Whence may be deduced for pure caoutchene (cf. discussion above): C, 88.0; H, 11.9%. $(C_5H_8)_{16}$ requires C, 88.2; H, 11.8%; *M*, 1088]. Within the limits of error of the determinations, the oxygen content is equivalent to the nitrogen content. The analysis is typical of those obtained for crude caoutchene from fresh latex and from plantation rubber.

The Nitrogenous Constituent.—It has been mentioned above that a quantitative separation of caoutchene and the major portion of the nitrogenous matter of rubber has not been effected. This is the more remarkable in that crude caoutchene dissolves readily and almost without swelling in the usual rubber solvents and in ether to give solutions which are remarkably mobile and in some

cases water-clear. The ethereal solution is opalescent, but prolonged centrifuging of both the ethereal and the benzene solution failed to remove any undissolved matter. Solutions of crude caoutchene were kept for 6 months in diffuse daylight, until their viscosity approached that of the solvent itself (Figure). Such solutions gave no evidence of the separation of insoluble matter (Found for dissolved matter: N, before exposure, 0.4; after 6 months' exposure, 0.4%). A further unsuccessful attempt to remove nitrogenous matter from crude caoutchene involved prolonged continuous extraction of a benzene solution with 90% formic acid (Found for extracted caoutchene: N, 0.38%). It has been shown by Wilkins (*Science*, 1937, **85,** 526) that this reagent quantitatively removes the protein from dried grasses. Low values for the nitrogen content of crude caoutchene have been observed only for specimens prepared from the dried solids of creamed latices (Found: N, 0.3, 0.1, 0.3, 0.1, 0.1, 0.2% for the products of various processes). The creaming of latex involves a partial separation of the larger and the smaller globules, the latter tending to remain in the serum. The above results therefore indicate that the smaller latex globules contain a higher concentration of the nitrogenous constituent than the larger. Other "low-nitrogen rubbers" of commerce do not come into consideration in this connection, since they are prepared by treatments designed to remove nitrogen chemically.

Caoutchol.—Crude caoutchol (10 g.), isolated from the organic non-hydrocarbon matter of rubber as described in the preceding paper, is heated under reflux for 1 hour with 1% aqueous caustic soda (200 c.c.). The cooled product is filtered off (a coarse, hardened paper is advisable), and the residue washed with water on the filter.

(*a*) The residue. For complete removal of alkali, the product should be repeatedly passed through the closed rolls of a mill fitted with a water spray. It is thus obtained as a thin, elastic, opaque sheet which may be dried in a vacuum over sulphuric acid in 24 hours. The resulting substance, *caoutchol*, is transparent, pale brown, and non-self-adhesive, and is extensible by at least 700% with immediate recovery to only 100% extension [Found: C, 85.3, 85.2, 85.4; H, 11.8, 11.8, 11.7; *M* (Rast), 1085, 1116, 1192; mean, 1131. $C_{80}H_{130}(OH)_2$ requires C, 85.3; H, 11.8%; *M*, 1125]. It has not a definite m.p., but softens progressively up to 100°, at which temperature it is a highly viscous, deep yellow fluid. In this condition it slowly oxidises in air (Found: Increase in weight after 24 and 48 hours at 100°, 0.29 and 2.07% respectively). It also slowly softens and oxidises in moist air at room temperature (28—32°). These reactions are being further investigated.

Depressions of the freezing point of benzene solutions of caoutchol were measurable, but are probably of doubtful significance (cf. the discussion of a similar phenomenon by Pummerer, Andriessen, and Gündel, *Ber.*, 1929, **62,** 2628, in connection with raw rubber) (Found: *M*, 3200, 7000, 1608, 3216). The Menzies—Wright method was not applicable owing to the tendency of solutions to froth when boiling.

Caoutchol (1.6 g.) in benzene (20 c.c.) was heated under reflux for 30 minutes with acetic anhydride (4 c.c.). After removal of benzene, the product was treated with hot water and with hot alcohol to yield a brown tacky substance, *caoutchol diacetate* [Found: C, 83.6, 83.8; H, 11.6, 11.1; *M* (Rast), 1227 ± 70. $C_{80}H_{130}(O.CO.CH_3)_2$ requires C, 83.3; H, 11.3%; *M*, 1208].

(*b*) The filtrate. The faintly opalescent liquid resulting after removal of caoutchol was acidified with sulphuric acid. A strong mercaptan-like odour was detected and a flocculent buff-coloured solid separated. The latter, collected, dried, and weighed, constituted 2—3% of the crude caoutchol. It appears to be a complex mixture of carboxylic acids. The sulphur-containing substance is retained in the aqueous filtrate, which has been shown to contain a small amount of a highly reactive substance. Further investigation is proceeding.

Viscosity measurements were made in the Höppler research instrument at 26—29°.

LATEX PRESERVATIVES

1. SOME PRELIMINARY EXPERIMENTS WITH SODIUM PENTACHLORPHENATE — "SANTOBRITE" —

BY

EDGAR RHODES

Introduction

The agent in general use as a latex preservative is ammonia, but certain users of preserved latex find its volatility and odour objectionable. Latex preserved with fixed alkalis is unpopular on other grounds and there have, for some time, been indications that a preserved latex containing only small quantities of ammonia and/or fixed alkalis might find markets.

All fresh field latex contains bacteria and the bacterial population increases at a great rate, producing acids which inevitably cause coagulation unless they are neutralized.

For successful preservation the latex must eventually be rendered sterile, otherwise coagulation by bacterial acids takes place, and the ideal preservative would be one which while itself having no adverse effects on the quality of the latex would, when applied in very small amounts, induce complete sterility in a few minutes, or in other words before dangerous amounts of bacterial acids had been produced. Such a latex disinfectant would be of very great value. Satisfactory preservation is obviously possible also with preservatives which are incapable of producing instantaneous sterility, provided the latex is given sufficient reserve of alkalinity to neutralise the bacterial acids produced during the hours or days which elapse before it becomes completely sterile.

Ammonia and the fixed alkalis do not induce sterility immediately, but if they are applied in sufficient amounts they provide in themselves sufficient reserve of alkalinity to neutralise the bacterial acids formed during the first few days before apparent sterility is induced. The bacterial population of latex and the effect of ammonia on it has been discussed in more detail by Beeley and Rhodes (1).

Earlier attempts to find preservatives alternative to ammonia and the fixed alkalis, have been mentioned by Rhodes (2), (3), (4) and (5) and in the course of this and later work it has become increasingly evident that most of the disinfectants which are extremely powerful at low concentrations in other liquid media, are less active in fresh latex, and require to be applied at much greater concentrations if they are to be even moderately effective.

Further, no non-alkaline disinfectant has yet been found which gives really satisfactory long period preservation in the total absence of some added ammonia or other alkali. Most non-alkaline disinfectants fail completely to preserve fresh latex in a fluid condition for longer than 24 hours at tropical temperatures, but many do so in the presence of 0.1 per cent of ammonia, which provides an alkali reserve during the first few days. The following quite arbitrary and apparently simple requirements have been used for some time at the Institute as a basis of first judgment on disinfectants:—

(i) When applied on the day of collection to latex containing 0.1 per cent ammonia in an amount not exceeding 0.3 per cent by weight calculated on the weight of latex, fluidity should be maintained for periods of at least three months at tropical temperatures and the latex should be found to travel satisfactorily in iron drums or tinned iron containers.

(ii) No dark-coloured deposits or discolouration should be produced, viscosity should be normal, and putrefactive odour and partial coagulation absent after a storage period of three months.

(iii) The disinfectant should preferably not be highly poisonous and the total cost of application should not exceed that of preservation with 0.75 per cent ammonia.

It has always been realised that a preservative which satisfied these minimum requirements might yet yield a preserved latex which would not be satisfactory in other respects, and the requirements have been used only as a first basis of judgment, satisfaction of them being taken to indicate no more than that the preservative was worthy of more extended trials.

Up to date a number of disinfectants have been found which easily satisfy the first requirement and notable among these are a number of organic mercury compounds of which mercuric cyanide is the best so far tested. In presence of 0.1 per cent ammonia this substance is effective when applied in amounts of the order of 0.05—0.10 per cent on the latex. No substance however (organic mercury compounds included) had until recently been found which appeared to satisfy all the requirements, and the following is a description of experiments with the first disinfectant which does appear to satisfy them reasonably well.

Experimental

Preservative

The material used in the trials was supplied to us by the Monsanto Chemical Company, St. Louis, Missouri, U.S.A.; it consists of sodium pentachlorphenate and is known by the trade names of "Santophen 20 S" or "Santobrite." It is obtainable

either in the form of small brownish-grey crystalline flakes or as briquettes. The dust is irritating to mucous membranes and causes sneezing when breathed. It is freely soluble in water.

The fact of free solubility in water is an advantage; on many estates it is only with some difficulty that latex having a dry-rubber-content of 38—40 per cent as specified in most R.T.A. contracts can be obtained, and it is therefore important that the added preservative solution be as small in volume as possible so as not to reduce the dry-rubber-content of the preserved latex very appreciably. In all the experiments to be described the "Santobrite" was applied in the form of an 18 per cent aqueous solution. It can, however, if necessary, be used at a concentration of 25 per cent.

Trials with Fresh Field Latex

In trials with fresh field latex the "Santobrite" solution was applied in amounts ranging from 0.1 to 0.75 parts solid "Santobrite" per 100 parts of latex. Typical results are given in Table I.

TABLE I

Parts Santobrite per 100 parts Latex	Days preserved in fluid condition
0.1	< 1
0.2	< 1
0.3	< 1
0.4	< 1
0.6	7
0.75	15

Trials with lightly-ammoniated Latex

(a) *Laboratory Trials*

In these trials the "Santobrite" was applied to latex which had been ammoniated to approximately 0.1 per cent NH_3, immediately on arrival from the field. Table II gives results obtained on small laboratory samples.

In confirmatory trials with 0.2 and 0.3 per cent "Santobrite" respectively on another lightly-ammoniated latex the sample containing 0.2 per cent "Santobrite" failed on the 95th day, while that containing 0.3 per cent "Santobrite" was still in good condition after 150 days.

TABLE II

Parts Santobrite per 100 parts Latex	NH_3 content of Latex per cent.	Days preserved in fluid condition	Condition at 100 days or at failure
0.1	0.07	2	Coagulated
0.2	0.07	98	Coagulated
0.3	0.07	>100	Good colour No putrefaction
0.4	0.07	>100	Good colour No putrefaction
0.6	0.07	>100	Good colour No putrefaction
0.75	0.07	>100	Good colour No putrefaction

(b) *Small-scale Shipment-trial of preserved Latex*

This trial was made with a single 4-gallon lot in an unfilmed tinned-iron container. The trial lot was shipped to the London Advisory Committee for Rubber Research (Ceylon & Malaya), Imperial Institute, London, for examination. Details concerning the batch at the time of shipment are as under:—

"Santobrite" Content	...	0.2 parts per 100 parts latex
Ammonia Content	...	0.08 per cent
Total Solids ...	...	39.2 per cent
Dry-Rubber-Content	...	5.6 centipoises
Colour	...	Good white
Odour	...	Good

The trial lot arrived at its destination in good fluid condition, with good white colour and with no evidence of putrefaction. After storage for a further period in London its condition in respect of colour and odour five months after preparation in Malaya was apparently unchanged. The stability on receipt in London was somewhat below average for preserved latex but it was not dangerously low. Similarly the strength of the dried film was 670 lb./sq. in., which is below average for ammonia-preserved latex.

"Santobrite" in Cream-preservation and Creaming

Trials were made with the object of exploring suitable conditions for the preservation of concentrated latex and the preparation of creamed latex of low alkalinity.

(a) *Laboratory Preservation Trials*

The results of preservation trials with (i) Centrifugal concentrate containing 60 per cent dry rubber and 0.1 per cent NH_3, and (ii) Tragon cream latex containing 53 per cent dry rubber and 0.1 per cent NH_3, are given in Table III.

TABLE III

Parts Santobrite per 100 parts latex	Centrifugal Concentrate		Tragon Cream Latex	
	Days preserved in fluid condition	Condition at 120 days or at failure	Days preserved in fluid condition	Condition at 120 days or at failure
0.10	>120	Good	85	coagulated
0.15	>120	Good	—	—
0.2	—	—	>120	Good
0.3	—	—	>120	Good

(b) *Laboratory Creaming Trials*

In the preparation of low-ammonia creams containing not more than 0.1 per cent ammonia, the choice of creaming agent is of some importance. Tragon seed gum (locust bean meal) is the creaming agent most commonly used in Malaya and its creaming efficiency is low at the low ammonia concentrations—0.2 per cent—required in the original latex in order to obtain a cream containing 0.1 per cent ammonia. Elsewhere in this issue details are given of a Rubber Research Institute patent for the use of tamarind seed as a creaming agent. The efficiency of this material is almost independent of the ammonia concentration of the latex and it therefore suggests itself as a suitable agent for the preparation of low-ammonia creams.

Whenever creaming is carried out in a latex containing not more than 0.2 per cent ammonia, there is a danger of the development of putrefactive odour either during the creaming period or shortly after, and on this account the presence of some additional disinfectant in the latex while creaming is in progress, is indicated.

Trials were made with tragon seed gum and with tamarind seed, in latices containing varying amounts of ammonia and "Santobrite," and it was found that, although the presence of "Santobrite" improved the creaming efficiency of tragon seed gum slightly at low ammonia concentrations, tamarind seed gave superior results. Rich creams free from putrefactive odour were obtained with tamarind seed from latex containing initially 0.1 per cent ammonia plus 0.3 per cent "Santobrite" calculated on the latex, and on the basis of these findings a batch of low-ammonia cream was prepared for shipment-trial. Details concerning this follow:—

(c) *Shipment-trial of "Santamcream"*

Two separate batches of cream were prepared and bulked together for shipment. In the preparation of each batch fresh latex was ammoniated to 0.1 per cent and treated with sufficient "Santobrite" to give 0.3 per cent calculated on the latex. The batch was then creamed by the application of sufficient of a 3-per-cent solution of tamarind seed to give 0.2 per cent of solid creaming agent calculated on the latex. After a creaming period of 48 hours in the case of the first batch and 72 hours in the case of the second, the cream was run off and treated with "Santobrite" solution sufficient to give a further 0.1 per cent "Santobrite" on the cream. The two batches of cream were combined and a 40-gallon trial-lot was shipped under the style of "Santamcream" to the London Advisory Committee in a black iron drum. At the time of shipment it had the following characteristics:—

Total Alkalinity due to Santobrite and ammonia	0.12 per cent calc. as ammonia
Ammonia content ...	0.055 per cent approx.
"Santobrite" content ...	0.25 per cent approx.
Total Solids	59.59 per cent
Dry-Rubber-Content ...	57.90 per cent
Viscosity	48.7 centipoises
Colour	Good white
Odour	Good.

It is reported that the trial batch arrived in London in good liquid condition, with excellent colour and without putrefactive odour.

Discussion and Summary

It is evident from Table I that "Santobrite" alone is not suitable for the preservation of fresh latex. From Table II it is seen, however, that when applied in an amount equal to 0.3 per

cent, to latex freshly ammoniated to 0.1 per cent NH_3, long-period preservation is possible. In spite of the fact that a small-scale trial-shipment containing only 0.2 per cent "Santobrite" travelled well and has maintained its good condition for five months, the results in Table II *et seq* are sufficient to indicate that 0.2 per cent "Santobrite" does not allow a sufficient margin of safety. An amount equal to 0.3 per cent "Santobrite" together with 0.1 per cent ammonia is considered desirable for the preservation of normal field latex.

"Santobrite" has been used successfully in the preparation and subsequent preservation of a trial batch of lightly-ammoniated creamed latex.

The total cost of preservation with "Santobrite" should compare favourably with that of simple ammoniation.

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Acknowledgements

The writer's thanks are due to the technical officers of the London Advisory Committee for Rubber Research (Ceylon and Malaya) for their examination and reports on the trial sample, and to Mr. K. C. Sekar for most of the laboratory work involved.

Kuala Lumpur

14th April, 1938

NOTES ON A VISIT TO INDO-CHINA

BY

J. H. Piddlesden

The writer visited Indo-China in April of this year and was privileged, by the courtesy of the directors and managers concerned, to visit many of the large rubber estates in that country. The object of these notes is to record some of the impressions obtained, paying particular attention to observations on estate factory equipment and operation.

General

The land in Southern Cochin China and Cambodia is flat or very gently undulating, and is free from the ravines and steep slopes so common in Malaya. It consists mainly of a light grey friable soil, and contains outcrops of red soil scattered like islands in it. The grey soil is of variable value but the red soil areas which are usually characterised by their great depth, are very fertile. The rubber estates of the big companies have naturally tended to become concentrated on the red soil. There seem to be no small-holdings of the type familiar in Malaya, owned and operated by Asiatics, but their place is taken by numbers of small estates which are usually owned by Europeans. These estates are operated by Asiatic managers and supervised in their spare time by the owners, who are frequently professional or business men. Such estates are naturally most numerous in the vicinity of Saigon.

The estates owned by the limited liability companies are organised in larger units than are common in Malaya. Five thousand acres is quite an average size to be served by a single factory, and there are several estates of more than twice this area. The reasons for this are firstly the flat terrain which renders the construction of roads easy, and thereby facilitates supervision of field work and transport of latex; and secondly the difficulty of obtaining an adequate water supply, which limits the choice of sites for estate factories. The country experiences a very pronounced seasonal variation in rainfall, and from November until April there is very little rain. Although this aggravates the difficulty of obtaining sufficient water, causes wide fluctuations in the yield of rubber, and introduces a grave risk of fire during the wintering season, it is not entirely a disadvantage. The complete absence of root disease in Indo-China is said to be largely owing to the dry periods.

An ample supply of Annamite and Tonkinese labour is available in the country. Both free and contract systems are used. In the former system the labourers are employed by the day from neighbouring villages and the estate takes no responsibility for housing them or providing medical attention. The contract labourers are drawn from the northern parts of the country, and are housed on the estates in villages of huts similar to the new cottage-type lines which are being built in Malaya. In addition to the wages the estate provides a rice ration, medical attention, and a contribution to the provident fund which is controlled by the Government. The total cost to the estate is about 40 to 45 piastre cents per day. At the present rate of exchange (*circa* 170 francs, *i.e.* 17 piastres, to £1 sterling) this is about half the cost of labour in Malaya.

The planting industry in Indo-China is of fairly recent development. The planted area has increased from 85,000 acres in 1925 to approximately 315,000 acres now. Most of this development took place between 1926 and 1932, by which time the industries in Malaya and the Dutch East Indies were well established and had carried out a considerable amount of research. Full use was made in Indo-China of the experience gained in other countries, as is shewn by the fact that one-third of the total area is budded with the best material that was available in 1930 to 1932. This factor, together with the rich soil, absence of root disease, organisation in large units, which require the minimum of supervision, cheap labour, and favourable rate of exchange, places Indo-China in a very strong position as a rubber-producing country. A good general account of The Rubber Plantation Industry in French Indo-China, by W. G. Birnie appeared in the *Bulletin* of the Rubber Growers' Association for June 1938. [**20** (1938) 239].

Factory Practice

Latex is usually transported by lorry. Transportation tanks which can be pushed on and off the lorry are in common use. The majority of these are of sheet steel though aluminium is coming into use. In some cases large steel tanks which are built on to the lorry or to a trailer are seen. In spite of the large areas served and the large volumes of latex handled, the latex is usually all in the factory by early afternoon. Anti-coagulants are regularly employed. Sodium sulphite is used in some cases. One group of large estates uses ammonia solution which is prepared by a distillation process from ammonium sulphate on the estates. Another group has evolved an anti-coagulant mixture containing sodium sulphite, with small added amounts of caustic soda and

para-nitrophenol. This is said to be as effective as sodium sulphite alone and more economical in use.

Factory Design and Lay-out

As stated above, the factories are usually designed to handle a large crop per day. Five to ten tons of rubber per day is considered quite normal, and one factory capable of making forty tons per day was visited. A straight-line production system is used. The latex is received in bulking tanks at one end of the factory and is usually delivered to fixed rows of coagulating tanks set at right angles to coagulum chutes which run the length of the factory to the sheeting batteries at the far end. Continuous sheeting is invariably used on the large estates. The rubber is cut and hung on to smoke-house trucks, which pass through smoke-houses generally of the tunnel type to the packing shed. The "tanks-on-trucks" system has recently been installed in one or two of the smaller factories where only one sheeting battery is required. Wide use is made of reinforced concrete in constructing the buildings. Standard sections are available for roof trusses, rafters etc. in this material. Good local bricks are also available and are widely used. Steel-frame or timber-frame buildings are less common.

Bulking Tanks

Large concrete bulking tanks lined with white tiles are in general use and appeared to be well liked. Many of them are built in two compartments, the smaller one into which the latex is discharged from the lorries, being separated from the bulking chamber proper by vertical gauze screens which serve as the initial strainers. The latex in nearly all cases is sieved again after dilution and settling. A few new rectangular aluminium bulking tanks of 3,000 litres capacity are in use. They employ a swivelling pipe inside each tank pivotted at the outlet near the base, with the free open end arranged to float just below the surface of the latex. By this means latex may be continuously withdrawn from the upper layers and the risk of disturbing the sludge during run-off is reduced to a minimum.

Filters

Several novel types of filters are used for straining the latex during transit from the bulking tanks to the coagulating tanks. Perforated aluminium sheet is popular in place of gauze as a filtering medium. One filter consists of an aluminium cylindrical vessel containing concentric cylinders of filter plates, with the coarser ones inside. Latex enters at the centre of the base, flows

outwards through the increasingly fine filter plates, and is drawn off from the side of the container. The filter cylinders can be withdrawn easily, for cleaning, and the apparatus is provided with a cover which enables it to be used under pressure.

In a second type perforated aluminium sheet is made into a sleeve about six inches in diameter by thirty inches long, closed at one end, and secured at the other by means of a bayonet fitting to a swivelling tee through which it is connected to the outlet cock. The latex from the bulking tanks is delivered into a trough in which several of these sleeves rest horizontally. The latex passes through the perforations and flows through the swinging joint to the outlet cock, and thence to the coagulating tanks. When the filter starts to clog the sleeve may be lifted into the vertical position, about the swivelling joint; the perforations are thus lifted above the liquid level, and flow ceases. The sleeve can then be removed for cleaning, and replaced. This device has been developed and patented by Mr. A. Denholm of the Société Indochinoise de Matérial Méchanique.

Another novel filter is made in the form of a hexagonal drum, each face of which consists of a readily-detachable perforated plate. The drum is mounted horizontally in two trunnions in a small tank into which latex is fed through a ball valve, so adjusted that the drum is immersed for about three-quarters of its depth. The liquid passes through the perforations into the drum, from which it flows *via* the hollow trunnion to a pipe which conveys it to the coagulating tanks. While the filter is in use it is occasionally rotated by hand to bring one of the clogged faces to the top, clear of the liquid. The plate can then be removed for cleaning, and replaced without interrupting the flow of latex. This device was developed by the Société Indochinoise des Plantations Réunies de Mimot and has been patented by that company.

Coagulating Tanks

Aluminium tanks designed for making continuous coagulum are used. They are constructed of sheet metal secured in steel or cast aluminium frames and no timber is employed in the structure. The sides and bottoms are smooth, and a separate frame which rests on top of the tank is slotted to hold the partitions. These are located at their lower edges by slotted beadings or combs, which are not attached to the tank but are held in place by hooks passing up between the plates and secured at the top by wing nuts. The separate frame carrying all the partitions can be raised or lowered at will, by a hand winch, or an electric crane. The normal working procedure is to assemble

the partitions in position in the clean, empty tank. The frame carrying the partitions is then hoisted and the lower beadings securing the partitions are fixed in place. When the latex and acid have been mixed in the tank, the partition assembly is lowered rapidly into place, the hooks securing the beadings are withdrawn and the tank is left overnight. Next morning the partitions are usually removed by hand, leaving the frame in place on the top of the tank, and the beadings resting on the bottom. All the partitions can be lifted out at once by hoisting the frame, but this may cause some tearing of coagulum, and presents no advantage, since no satisfactory method has yet been found for cleaning the partitions without removing them from the frame. This system therefore offers no advantage over the Malayan one during machining, but it saves considerable time in placing the partitions in the latex during coagulation. This is particularly important in factories where a large number of tanks must be coagulated before the latex deteriorates.

The standard tanks are 3 metres long, by 1.1 metres wide by 45 centimetres deep and contain 99 partitions, thus giving 200 sheets. With coagulation at 16 per cent dry-rubber-content each tank will yield about 425 lb. of dry rubber. The coagulum is wide and is only about $1\frac{1}{8}$ inches thick. This use of thin wide coagulum facilitates machining and plays a large part in securing the high battery outputs which are obtained in Indo-China. It also renders unnecessary the rather complicated corrugations in the sides of the coagulating tanks familiar in Malaya, which are used to avoid the thick patches formed in continuous sheet at points where the coagulum passes round the ends of the partitions. Coagulation is usually carried out at higher dry-rubber-contents than are used in Malaya. The standard of one group is 16 per cent and others work up to 18 or 20 per cent dry-rubber-content.

Tanks identical in size with the standard tank but containing 109 partitions are used in some places, and on one large estate tanks 5 metres long were observed. On another estate there are three tanks each 150 feet long set lengthwise in the factory with the bulking tanks at one end, and a sheeting battery for each tank at the other end. Each tank is divided into ten sections by means of fixed partitions. Two of the tanks have inlets in the base of each section and latex enters from below, through an aluminium pipe connected to the filter. This minimises the formation of froth. In the third tank the fixed partitions are cut away to form weirs, and when latex is admitted it fills the first section, overflows to the second, and so on, until the whole tank is filled. Slats are then fitted over the weirs, the latex in each section in turn is mixed with acid, and the partition assembly for the section is lowered into place by an overhead travelling electric crane.

The tanks are provided with a 3-inch lip which allows them to be flooded, and the coagulum from one section can be floated down to the machine, over the top of the other sections.

Coagulating Equipment

Where the standard tanks are in use flooding is not normally adopted. A central coagulum chute full of water is used to float down the coagulum but there is, in most cases, a gap between the ends of the tanks and this chute, bridged by a small portable chute section, which is used to transfer the coagulum from the tank to the main chute. In large factories the latter is usually wide enough to carry two ribbons of coagulum side by side, and is divided at the end to feed two sheeting batteries simultaneously.

In one case an acid tank is arranged on rails over the central chute so that it can be pushed opposite each tank in turn, and the measured quantity of dilute acid delivered directly into the acid distributor resting on the coagulating tank. This distributor consists of an aluminium tube the length of the tank, with a narrow longitudinal slot in it. The tube is pivoted at each end in a small block which rests on the edge of the tank. The tube is filled with acid through an inlet hole while the slot is at the top, the inlet is then closed, and the tube is rotated to bring the slot to the bottom. The acid then falls as a thin sheet along the length of the tank. While the acid is running in, the tube is caused to traverse the width of the tank by sliding the mounting blocks along its edges. This gives an excellent distribution of acid. A novel type of mixer is used. This consist of an aluminium sheet almost the full width and depth of the tank, in which $\overline{\underline{\mathrm{T}}}$ shaped cuts are made, the two tongues so formed being bent out from the plane of the sheet in opposite directions to an angle of 45°. A stiffening bar with a handle at each end is fixed along the top edge of the sheet and carries rollers which run along the edge of the tank. This mixer is pushed to and fro along the tank by two labourers. It is very efficient and three or four passes are sufficient for satisfactory mixing.

Sheeting Batteries

A number of the Huttenbach sheeting batteries, of the type well-known in Malaya are used. Most of these machines have been altered, by shortening the main frame and the driving shafts, and bringing the pairs of rollers closer together. This modification is said to give more efficient working. Sheeting batteries produced by two Saigon firms are also widely used. One of them, Société Indochinoise de Matérial Méchanique, manufactures machines having four or five pairs of smooth rollers and a

pair of marking rollers, all set close together and driven by chains in the conventional way. The other, J. Cairns & Co., also makes machines having five and six pairs of rollers again set close together but uses the flat-faced type patented by Reginato for the first two pairs. These machines are all designed for working with continuous coagulum, and are very well made and efficient. In many of them the rollers are mounted in ball bearings and special devices are incorporated for the fine adjustment of the roll nips. In all cases the batteries are driven by electric motors, and a variable speed device is incorporated in many of the drives so that the speed of the battery can readily be adjusted to suit the conditions. The standard rollers are six inches in diameter by twenty-six inches long, and bronze mantled marking rollers are used in all cases. It was noticed that there is a comparatively small increase in the width of the coagulum during machining. This is probably owing to the fact that the coagulum entering the machine is thin, and that the machines are always set to keep the coagulum under slight tension during its passage between the rollers. At the end of the dry season when these observations were made most factories were operating on comparatively small crops and the machines were set for a "comfortable working speed" rather than for peak outputs. Under these conditions it was estimated that the average output was about 2,500 lb. dry rubber per machine per hour. In one observed test an output rate of 3,660 lb. dry rubber per hour was recorded on a full tank coagulated at 16 per cent dry-rubber-content, and it was claimed that over 4,000 lb. per hour can be achieved by increasing the battery speed. The sheet is one-eighth of an inch thick and free from machine faults. The roll speeds are not very much higher than those used in Malaya, and the higher outputs are due largely to the difference in the coagulum, the use of continuous sheet, and care in setting the machines and training the labour force.

An agency for the Guthrie Automatic Sheeting Batteries was established in Saigon early this year but no figures are available for the performance of these machines in conjunction with the tanks used in Indo-China. J. Cairns and Co. have recently placed on the market a four-roll automatic machine designed to handle either continuous coagulum or separate sheets. The machine comprises three pairs of flat-faced rollers and a pair of bronze markers mounted on a steel frame which slopes slightly from the feed end to the markers. The frame is very carefully filed true so that the bearing housings are mounted perfectly squarely. Ball bearings are used with a well-designed chain drive which runs in an oil bath and requires only a pint of oil to keep it lubricated. The whole machine when assembled is only one

metre long and can be rotated by a single finger on the clutch. Provision is made for the fine adjustment of the nip of each pair of rollers and the chutes are of polished stainless steel. This machine is stated to be capable of rolling 3,000 lb. of continuous sheet per hour, and has also been tested on separate sheets of coagulum one-and-a-half inches thick, which it handles satisfactorily.

Washing and Cutting

One of the main difficulties in working with continuous sheet is that of dealing with the long ribbon of machined rubber issuing from the marker, and arranging a method of cutting and hanging which will keep pace with the output. This problem has been solved in Indo-China. The continuous strip of machined sheet passes through a washing machine consisting of two hollow aluminium rollers mounted so that they can rotate freely in a frame of iron pipe. The sheet passes under the first roller and up over the second one. Horizontal perforated water pipes are mounted between the two rollers so that the sheet is sprayed

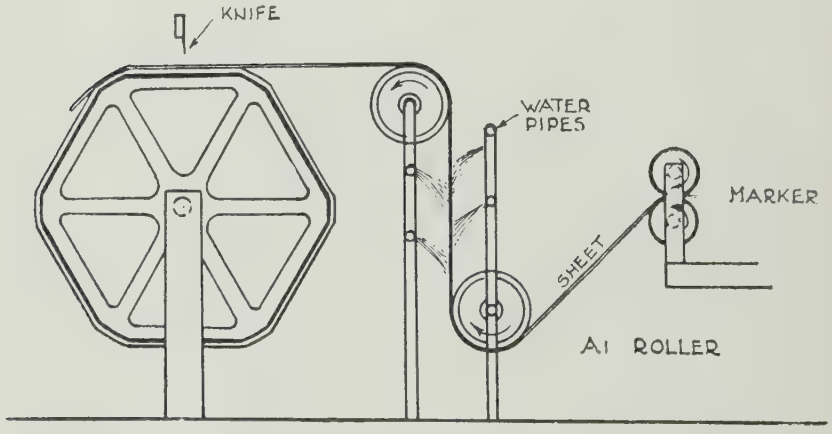

Fig. I

vigorously on both sides with clean water, as it passes through. From the upper roller the sheet passes on to a hexagonal drum which is free to rotate about a horizontal axis. The labourer who cuts the sheet, rotates this drum by hand, and a second man picks off the cut pieces and hangs them on a *berotie* in an adjacent rack. Two more labourers are employed to transfer the filled *beroties* to the smoke-house truck and place the empty ones in position near the end of the machine. The washing and cutting

devices are illustrated in Figure I. Both are cheap and simple to construct. The cutting drum consist of two end castings of aluminium or iron secured to a shaft which is carried in bearings supported by short stanchions. The faces of the drum are of hard wood.

Power Supply

The sheeting batteries on the large estates are all driven by electric motors. Each estate is equipped with its own central power station containing Diesel-generator sets. In many cases these are very large. The usual arrangement is to use a large Diesel engine which is coupled directly to the driving shaft for the crepe battery and to drive a dynamo from this shaft. A small stand-by generating set is used when the crepe machines are not working. Care is always taken to ensure that there shall be an emergency supply if the main source of power breaks down. Electric motors and in fact all items of equipment are standardised as far as is possible throughout a group, so that a limited supply of stores and spares will suffice for the whole group.

Drying

Drying and smoking are usually carried out in three or four days in smoke-houses of the tunnel type. On one group two tunnels are employed, in each of which the rubber remains for two days. The furnaces are at the side of the building, far below ground level, and the flues are parallel to the rails. A more recent type is designed for drying in three days—one day in the first building, which is well ventilated and has provision for draining off dripped water, and two days in a second building. Both buildings are of the tunnel type, with the flues parallel to the rails. The roof is continued between the two houses and the furnaces are accommodated below the rails in this space.

On another group which consists mainly of very large estates, three blocks of tunnels are used. The first two, which are for the first and second days' drying respectively, are heated by wood fires at each end. Each flue and pair of furnaces serves two tunnels. The third block is heated by steam, and in times of high output completes the drying in three days, but it is preferred to reduce the temperature and leave the rubber in this block for two days when space permits. One estate is using enlarged Subur-type smoke-houses, which hold four trucks each carrying 1,600 lb. of rubber in each chamber. Two furnaces are used for each building and the conventional flue system is duplicated. As in Malaya, difficulty is experienced with water dripped from the

sheets after they enter the smoke-house, and in most cases provision for drainage is made. On one estate it has been found that by heating the rubber vigorously at first this dripping can be completed in an hour. A large smoke-house has therefore been designed in which the rubber can be dried in four days in a single building. Steam-heating is used and supplementary wood fires provide the smoke. Provision is made for close control of both temperature and ventilation, and for the rapid removal of water. The wet sheet is strongly heated with little ventilation for the short while until dripping ceases, the temperature and ventilation are then adjusted and drying proceeds in the normal way.

All the smoke-houses referred to are very well built of brick and reinforced concrete, and in many cases double brick walls containing cavities filled with charcoal are used. The large sizes and the expensive type of construction used are likely to prevent these designs from becoming of practical interest in Malaya.

Dry Rubber and Packing

Most of the finished sheet inspected was of good No. 1 quality.

The sheet is usually a little thicker and heavier than Malayan rubber and is smoked to a light medium colour. In some cases it seemed slightly tacky, and this can be ascribed in part to several causes, including the presence of large proportions of rubber from young budded trees, the free use of anti-coagulants, rapid drying, and, in some cases, very little washing. If washing is reduced to a minimum serum-solids remain in the rubber and a slight increase in the weight of the dry crop is achieved. Some estates find it possible to do this without incurring the defects of rust, mould etc. usually associated with inadequately washed sheet.

The majority of estates in Indo-China, including even the very large ones, carry out their packing with the aid of only one or two hand-operated presses. Instead of a special structure built on the press to support the cases during compression, separate boxes are used. These strong boxes have hinged sides and detachable tops, and are mounted on small castors. An empty plywood case is placed in one of these boxes and the sides are closed by hasps and pegs. The case is filled, and the lid of the strong box is placed on top of the rubber. The box is wheeled under the press and compressed until the lid can be secured down by its hasps and pegs. The press can now be opened and is ready to receive a second charge while the recently-compressed rubber is kept under pressure in the strong box for fifteen to thirty minutes. The pegs can then be knocked out and the case is ready for nailing and marking. These boxes not only allow each press to deal with a much larger

quantity of rubber, but also provide a ready means of transporting the cases to and from the press.

Crepe Manufacture

Nearly all the large estates are equipped with crepe-making machinery and many grades of this product are made, though the bulk of the work is in making off-quality rubber. The quantities of scrap are sufficiently large to make careful grading worth while and pale crepes of high quality are produced from clean cup lump, pre-coagulated latex, etc. Most of the newer installations consist of batteries of five machines having rolls sixteen inches in diameter and thirty-two inches long. The amount of machining given depends upon the grade being produced, but a typical example is five times through the first machine, four through the second, two through the third, and once each through the fourth and fifth machines.

Crepe Drying

Single-storeyed buildings are used and artificial heating is employed in conjunction with electric fans for air circulation. Heat is supplied either by steam or hot water pipes. Most of the drying sheds are very simple in design and are very effective, but would be of no interest in Malaya where steam and electric power are not usually available on the estates.

Conclusion

The visitor from Malaya cannot fail to be impressed by the fine layout and lavish equipment of most of the estate factories in Indo-China or to feel that in some ways they appear to have surpassed Malaya. A closer inspection reveals that the apparent superiority is due to the inherently different conditions in the two countries, and some of the apparent improvements could not be economically applied in Malaya. The differences are mainly due to the larger crops handled in each factory, the recent growth of the industry, and the currency in Indo-China. The centralisation of factory work could not be carried out to the same extent in Malaya as is possible in Indo-China, owing to the more difficult terrain. Existing serviceable machinery cannot be scrapped and replaced out of hand unless the saving in production costs will be large. The currency is a very important factor and one over which the rubber producer has no control. The present rate of exchange is very approximately two piastres per dollar, but the purchasing power of the piastre in Indo-China remains almost equal to that of the dollar in Malaya.

Acknowledgements

While in Indo-China the writer visited the following companies:—

Société Indochinoise des Plantations d'Hévéas

Société des Plantations des Terres Rouges

Michelin et cie

Société des Caoutchoucs de l'Indochine

Société Indochinoise des Plantations Réunies de Mimot

Société Indochinoise de Matérial Méchanique

Messrs. J. Cairns & Co.

Messrs. Diethelm & Co.

and desires to express to the staffs of all these companies his thanks for the generous hospitality received and the readiness with which information was placed at his disposal. He is particularly grateful to Mr. W. G. Birnie, General Manager of the first-named company, who acted as his host for a large proportion of his stay and who devoted so much time and trouble to shewing him round and explaining conditions in Indo-China.

Kuala Lumpur

8th October, 1938

CREAMING LATEX WITH SYNTHETIC CREAMING AGENTS

BY

EDGAR RHODES AND K. C. SEKAR

As a result of work carried out at the Rubber Research Institute, British Patent No. 476,073 has been obtained. The text of this patent follows:—

Patent Specification No. 476,073

Application Date: Oct. 22, 1936. No. 28735/36.

Complete Specification Left: July 13, 1937.

Complete Specification Accepted: Dec. 1, 1937.

COMPLETE SPECIFICATION

Improvements in and relating to the Concentration of Latex

We, RUBBER PRODUCERS RESEARCH ASSOCIATION, of 19, Fenchurch Street, London, E.C. 3, a Body Corporate duly organised under the Laws of Great Britain, do hereby declare the nature of this invention (a communication from Edgar Rhodes and Chandra Sekaran, both British Subjects, and both of Rubber Research Institute of Malaya, of Kuala Lumpur, Federated Malay States), and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to the concentration of latex by creaming and has more especial reference to processes wherein creaming agents are added to the rubber latex to accelerate creaming and obtain a stable cream rich in rubber.

Processes for the concentration of latex by creaming according to the present invention involve the presence as creaming agents of water soluble derivatives of the fatty alcohols containing between 6 and 18 carbon atoms per molecule, for instance the sodium sulphonate of the mixed alcohols obtained by the hydrogenation of coconut oil or sulphonated lauryl alcohol.

The latex subjected to the creaming process may be fresh or preserved and it has been found that after a short period of

creaming, a stable thick and pasty cream of high dry rubber content is obtained without it being necessary to add ammonia or other stabiliser and in fact of such stability as to be coagulable with acid only under the utmost difficulty.

In a specific example of one mode of carrying out the process according to the invention 100 ccs. of fresh latex having a D.R.C. of 34.7% are mixed with 10 gms. of the sodium salt of the sulphonated alcohols derived from the hydrogenation of coconut oil, and of which the chief constituent is lauryl alcohol, as sold under the Registered Trade Mark "Sulphonated Lorol" dissolved in 10 cc. of water. 100 ccs. of the mixture are set up for creaming, the serum level being noted at intervals. After three days the separation line between cream and serum remains stationary, and 56 ccs. of serum can be run off.

The residual cream has the following composition:—

Total solids ... ... 70.3 by weight

Dry rubber content by alcohol coagulation ... 65.1% by weight and is in the form of a thick paste of extreme stability on the hand rubbing criterion since it requires to be rubbed into a very thin film before coagulation takes place.

It will be understood that the invention is not limited by the foregoing example and comprehends processes for the concentration of latex by the addition of creaming agents of the range aforementioned with or without other agents such as carob seed gum according to our Patent No. 430,935, in the presence or not of alkaline or colloidal stabilisers, to give stable creams rich in dry rubber content without resort to expensive plant and procedure.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:

1. A process for the concentration of rubber latex by creaming involving the presence as creaming agent of a water soluble derivative or water soluble derivatives, of fatty alcohols containing between 6 and 18 carbon atoms per molecule.

2. A process for the concentration of rubber latex by creaming, according to Claim 1, wherein the creaming agent comprises sulphonated lauryl alcohol.

3. A process for the concentration of rubber latex by creaming, according to Claim 1, wherein the creaming agent comprises the sodium salt of the sulphonated alcohols obtained by the hydrogenation of coconut oil.

4. A process for the concentration of rubber latex by creaming, according to any of the preceding claims, substantially as described.

5. Stable latex pastes when prepared by the creaming processes according to any of the preceding claims.

This patent will shortly be registered in the Straits Settlements and the various States of Malaya.

Kuala Lumpur

14th February, 1938

CREAMING LATEX WITH TAMARIND SEED POWDER

BY

EDGAR RHODES AND K. C. SEKAR

As an outcome of the continued search at the Rubber Research Institute for useful cheap creaming agents, British Patent No. 474,651 has been obtained. The text of this patent follows:—

Patent Specification No. 474,651

Application Date: Aug. 24, 1936. No. 23187/36
Complete Specification Left: June 14, 1937
Complete Specification Accepted: Nov. 4, 1937

COMPLETE SPECIFICATION

Improvements in and relating to the Concentration of Latex

We, RUBBER PRODUCERS RESEARCH ASSOCIATION, of 19, Fenchurch Street, London, E.C. 3, a Body Corporate duly organised under the Laws of Great Britain (a communication from Edgar Rhodes and Chandra Sekaran, both British Subjects, and both of Rubber Research Institute of Malaya, of Kuala Lumpur, Federated Malay States), do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to the concentration of rubber latex and has more especial reference to processes for the concentration of ammoniated field latex by creaming wherein creaming agents, usually colloid substances, are added to the latex and cause or accelerate its separation into an upper layer of concentrated latex cream and a lower layer containing the serum constituents.

In our Patent Specification No. 430,935, a process for the concentration of rubber latex by creaming is described which involves the addition as a creaming agent of carob seed gum consisting essentially of the hemi-cellulose material extracted from the seeds of the locust or carob bean.

According to the present invention the concentration of latex by creaming is effected by the addition of the seed powder obtained from legumes of the tribe Amherstieae of the sub-order Caesalpinieae, more especially the tamarind tree (tamarindus indica) which tree is very common in South India.

Preferably the creaming agent takes the form of an aqueous solution of powder obtained from roasted and decorticated seeds of the tamarind tree.

In the practice of the invention the seeds are roasted until the husks become brittle and are easily removable. After shelling the seeds are ground and a solution preferably of 3% concentration is prepared by boiling the powder with the appropriate amount of water for one hour.

The solution obtained which is smooth and viscous can be added to the latex in an amount calculated to give 0.3 part by weight of tamarind seed per 100 parts of the water phase of the latex which has advantageously been subjected to a preliminary preservation treatment with ammonia to give it an ammonia content of 0.5% to 1.5%.

It has been found that there is no advantage in employing large amounts of the creaming agent, maximum creaming efficiency being obtained with a comparatively small amount of creaming agent which is illustrated by reference to the results of experiments shown in Table I.

TABLE 1

	Volume of latex taken (ccs.)	Volume of 3% tamarind seed solution added (ccs.)	Parts by weight of tamarind seed per 100 parts latex water phase	Ammonia in latex Per cent.	Dry rubber content of cream after 48 hours. Per cent.
Ex: 1.	465	35	0.35	1.0	59.3
Latex A.	450	50	0.50	1.0	57.4
Ex: 2.	465	35	0.35	1.0	57.8
Latex B.	450	50	0.50	1.0	55.4

It has also been observed that relatively high ammonia concentrations in the latex are unnecessary in order to obtain maximum creaming efficiency, as shown by the examples in Table 2, in which two latices were ammoniated to 0.5%, 1.0% and 1.5% both giving creams of similar dry rubber content in each case.

TABLE 2

	Volume of latex taken (ccs.)	Volume of 3% tamarind seed solution added (ccs.)	Ammonia in latex Per cent.	Dry rubber content of cream after 48 hours. Per cent.
Ex: 1.	465	35	1.5	57.2
Latex A.	465	35	1.0	57.8
	465	35	0.5	57.9
Ex: 2.	465	35	1.5	58.9
Latex B.	465	35	1.0	59.3
	465	35	0.5	59.2

Tests have also shown that the creaming agent is best added in the form of a strong solution in order to obtain maximum creaming, a 3% solution having been found most suitable. The results of experiments using the creaming agent in the form of 2 and 3% solutions respectively are shown in Table 3.

TABLE 3

	Volume of latex taken (ccs.)	Volume of tamarind seed solution added (ccs.)	Tamarind seed solution added at a percentage concentration of	Parts by weight of tamarind seed per 100 parts latex water phase	Dry rubber content of cream after 48 hours. Per cent.
Same Latex	225	25	2	0.35	57.2
Crop	93	7	3	0.35	59.2

The following is an example of carrying out the process:—

A quantity of tamarind seed was roasted until the seed coat became brittle and rubbed off easily. The kernels were ground into a fine powder, and the creaming agent prepared by adding 307 grammes of the powder to 2¼ gallons of water and boiling for one hour. The resulting solution was then added to 31 gallons of field latex having a dry rubber content of 30.7% ammoniated to 1.27% and the mixture allowed to cream in a cylindrical vessel arranged so as to permit of the cream being run off without disturbing the serum. After creaming for 38 hours approximately 16.5 gallons of concentrated latex were obtained having a dry rubber content of 58.3% and an ammonia content of 0.6%.

By the present invention improved processes for the concentration of latex by creaming are obtained providing creams rich in rubber after a period of from 2 to 3 days with small quantities of a creaming agent which is readily and cheaply obtained, and which tends to inhibit or reduce after-creaming and furnish a stable product of high dry rubber content.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A process for the concentration of rubber latex by creaming, consisting in the addition to the latex as creaming agent of a material obtained from legumes of the tribe Amherstieae of the sub-order Caesalpinieae, more especially the tamarind tree (tamarindus indica).

2. A process for the concentration of rubber latex by creaming according to Claim 1, wherein the creaming agent takes the form of an aqueous solution of powder obtained from roasted and decorticated seeds of the tamarind tree.

3. A process for the concentration of rubber latex by creaming according to Claim 2, wherein the aqueous solution contains approximately 3% of the seed powder.

4. A process for the concentration of rubber latex by creaming according to Claim 3, wherein the creaming agent is added to the latex in a proportion giving approximately 0.3 part of seed powder per 100 parts of the water phase of the latex.

5. A process for the concentration of rubber latex by creaming according to any of the preceding claims, wherein the creaming agent is prepared by roasting the tamarind seeds until the husks become brittle, thereafter removing the husks, grinding the seeds and boiling the powder so formed in the appropriate amount of water.

6. A process for the concentration of rubber latex by creaming substantially as described.

7. Rubber latex concentrated to a dry rubber content of over 55% when prepared by the creaming process according to any of the preceding claims substantially as described.

This patent will shortly be registered in the Straits Settlements, and the various States of Malaya. Producers are asked not to overlook the broad terms of British Patent No. 226,440 of Isidor Traube.

Kuala Lumpur

9th February, 1938

REPLANTING AND MALARIA

The Malaria Advisory Board invites the attention of all concerned with the management of estates to the danger of malaria resulting from the replanting of rubber. This danger is greatest in hilly country where the removal of old rubber provides ideal conditions of prolific breeding of *Anopheles maculatus*. Not only is there a great increase in breeding in streams and drains, particularly when these become blocked by trees being felled across them, but pits left by the uprooting of trees, holes prepared for replanting, silt pits and backward sloping terraces may all provide ideal breeding places.

It is suggested that, where possible, streams and drains should be put in order before felling and care taken to avoid blocking the drains by fallen timber. Pits left by the uprooting of old trees should be filled immediately if they are liable to retain water, and holes prepared for replanting should not be left open longer than is absolutely necessary. The Rubber Research Institute advises that: "There is no necessity to leave the holes open for any longer than is necessary to check the actual work of digging them." (*The Planter*, September 1938). In many places silt pits and terraces are liable to retain water and measures should be taken to enable this to drain off. With the growth of cover plants such breeding places may become obscured, but are still a source of danger.

These measures should not be confined to a half mile radius from human habitations. When intensive breeding is allowed to develop beyond the half mile limit the value of anti-malarial measures in the controlled area may be largely nullified.

Mother Earth, being Letters on Soil addressed to Professor R. G. Stapledon, C.B.E., M.A., by GILBERT WOODING ROBINSON, SC.D.

(London: Thomas Murby & Co. 1937. Price 5s. 6d. pp. viii+202)

The purpose of this excellent little book is well explained by the extracts which follow. The preface reads:

To the General Reader

Gentle Reader!

" I have addressed these Letters on Soil to an old friend " and colleague who is probably better known to the public " than I am. Although he may not agree with all that has " been written herein, I know he will read them with attention, " because they are about the Soil, which is the Land. And " because so many have read what he has written about the " land, I dare to hope that some may read these letters with " interest, for they deal with matters on which we ought to " think rightly. The affairs of the soil may not have the " strange magnificence of the outer universe or the curiosity " of the inner recesses of the atom; but they touch our daily " life more intimately. So I commend them to your notice " and ask your indulgence for the homeliness of my story."

Here are extracts from the first, introductory, letter:

My dear Stapledon,

" I have already written one book on soils..... " But I have been urged from more than one quarter to write " a smaller book on soils with a rather different appeal..... " .....It should be, I think, a book in which the " more technical aspects of the subject are less severely " treated.....a book in which the essential knowledge about " soils is presented in clear perspective; a book that will give " to workers in other fields,....., all they need " to know for the benefit of their own studies. But I have " ventured to cherish a further hope, namely, that I might " write a book that would interest the general reader, perhaps " even the farmer and the landowner, in the story of the soil, " .....

" For the past two or three years, I have been turning " over in my mind the idea of this little book on soils;..... " .....And now it has occurred to me to cast " my thoughts into the form of "Letters on Soil".....

"..... Perhaps the chief consideration was the possi-
"bility that it offered of speaking in a more intimate and
"direct way than in formal writing.

"The success or failure of a series of letters must depend
"in no small measure on the kind of person to whom they
"are addressed. And here, my dear Stapledon, I count it a
"real and happy inspiration to have thought of you as a possi-
"ble target for my epistolary shafts. You are vitally interest-
"ed in the Land, and the Land is the Soil, even although you
"may be a little doubtful of the value of soil scientists, if not
"of soil science itself.

"And now may I make a digression? I have just referred
"to my subject as soil science. I do not propose to use this
"barbaric term in these letters: I prefer to speak of my
"subject as pĕdology, a term having behind it nearly a genera-
"tion of use in many countries, and respectably derived, like
"most philosophical terms, from the Greek (πέδον = ground or
"earth). I know that there is a possibility of confusion with
"pedology (more correctly pædology from παῖς = a child). But
"I am not aware that this term has any wide-spread use, and,
"in any case, I am loth to pander to ignorance of Greek.
"For this latter reason, I refuse to admit the objection that
"pedology might seem to imply the study of feet! As for
"soil science," I have already called it a barbarism, for such
"I hold it to be. If soil science, why not "rock science," and
""plant science," and "stuff science"? Personally, I depre-
"cate the use of the term "science" at all and would prefer
""natural philosophy." I am loth to describe myself as a
"scientist, but I should be proud of the description "natural
"philosopher." No more, then, of soil science.

"To return from my digression, I know that you are deep-
"ly interested in the application of scientific theory to practice.
"You would hold, I think, that the value of pedology lies in
"its application to practice. But if I thought that your interest
"in the soil was simply utilitarian, I should feel that we had
"little common ground. I cannot help feeling that you have
"a deeper interest or you could not have written "The Land,
"Now and To-morrow." You love the land, and that means
"the soil, for its own sake. And I am equally sure that all
"the great leaders in agricultural history have loved the land
"for its own sake, and have found in its cultivation the expres-
"sion of their genius. Farming is a vocation, not a trade.

"I hope in these letters both to interest you in the soil as a
"wonderful work of Nature—a part of a still greater pattern
"—and also to satisfy, so far as I am able, your thirst for
"useful information. What I do not propose is to write a

"concise manual of soil improvement. I shall try rather to "give you a series of essays on the soil, viewed from the "philosophical standpoint. It is the standpoint that appeals "to me, for if I may, without profanity, borrow from the "language of mysticism, I am attracted rather to the con- "templative than to the active life, although I know that the "good life requires a due balance of both.

" I have often attempted to vindicate the philosophical "approach to problems of the soil and I will affirm again that "I believe this to be the only approach that gives any hope of "real progress. Great inventions (many of which I deplore) "have generally sprung from the application of principles dis- "covered by pure scientists and not from *ad hoc* research. "And, in the same way, I am sure that, as the principles of "the soil and its life are discovered, applications (possibly "deplorable) to the practice of agriculture will follow "naturally.

" Unfortunately, the study of the soil was, until recently, "strictly tied to agriculture as a branch of agricultural "chemistry, and with disappointing results. Only during the "present century has the soil been recognized as a natural "body to be studied for its own sake by philosophical methods. "This new approach is already justifying itself. Practical "problems, such as reclamation of land from the sea in Hol- "land, reclamation of alkaline irrigated lands in America and "elsewhere, and problems of soil conservation in many lands, "are being successfully tackled by the use of principles derived "from the philosophical study of soils.....

" Remember that pedology is one of the youngest branches "of natural philosophy and that it cannot be expected to "provide a solution for all problems. Consider the probable "state of geology if it had been strictly tied to mining and "quarrying for the first century of its existence. And remem- "ber that the problems of crop production lie as much in the "province of the plant physiologist as in that of the pedologist. "The master-problem of crop production is that of the contract "between soil and plant. If the nature of this contract is "once understood, the solution of problems of crop growth "follows naturally. This problem will not be solved by pot "and plot experiments, but by the fundamental investigations "of plant physiologists who are acquainted with the nature of "the soil medium.....

" I would wish everyone who is attempting to express him- "self by growing crops to become "soil-conscious" (to use "a barbarous modern expression). Believe me, my dear "Stapledon, the soil has something to do with your problems

"and you cannot ignore it or dispense with studying it. You "are primarily interested in growing crops and grass, and I "cannot but believe that, if the fundamental principles of the "soil are understood, you and your colleagues, rather than "the pedologists, will find their applications to practice.

" The letters I am about to write will form no systematic "course of instruction. They will not form even an elementary text-book of pedology. They are to be considered "rather as a series of essays, or even meditations, on topics "relating to the soil. And because I am writing for other "readers also, I have tried to simplify my narrative.....

" .....

" I am not sure that the general public is really interested "in soil. I notice two types of reaction when I am introduced "to people as a soil expert (a title I should never claim). "Either the word "soil" suggests some ribald joke as to "my occupation, or else my interlocutor asks me if I can tell "him what is good for his garden! I have rarely met anyone "interested in the soil for its own sake.

" I believe that the story of the soil is as interesting as "that of any other part of the great Universe, even although "its transactions are fulfilled beneath our feet.....

" .....

Ever yours,

G. W. R.

Professor Robinson occupies the chair of Agricultural Chemistry at the University College of N. Wales, Bangor. He is an international authority on soils. The above extracts will suffice to give an idea of the nature and style of the book, which can be heartily recommended to any reader interested in the soil, whether for its own sake or as a medium in which rubber trees grow. The soil scientist (save the mark!, I should have said pedologist) will also read it with interest; not because he will find any new facts therein, but because it must gain his admiration for the clarity, simplicity and attractiveness of the way in which facts and principles which are well-known to him, are presented to the non-expert reader.

There are seventeen letters in all, of an average length of twelve pages. Their titles, in order, are: Introductory; Soil or *A* Soil; Soil Material; Humus; Structure and Tilth; The Soil Profile; Some Typical Soils; Soil Moisture; Soil Fertility; Manures and Fertilizers; Lime; Soil Surveys; Arable, Grass, and Forest; Our

Agricultural Soils; Waste Lands; Corruptio Optimi Pessima, and Concluding Reflections.

The extracts from the introductory letter, printed above, show the author to be somewhat of a purist. The reviewer takes leave to question the aptness of the word "barbarous" as applied to the terms "Soil-Conscious" and "Soil Science," and he takes a wicked joy in objecting to the use of the word "fertilization" (p. 5), which already has such an unambiguous and generally accepted meaning in connection with the reproductive process of plants and animals, when the good old word "manuring" so much more suitably and correctly describes the application of plant food,—or should I say "plant nutrients," to the soil.

H. J. P.

Synthetic Rubber BY W. J. S. NAUNTON (*Macmillan, London*) 162 pages.

Into the scope of quite a small and very well illustrated book Dr. Naunton has brought together for the first time a great deal of information which was previously scattered. In nine chapters he surveys the whole field of synthetic rubber-like materials, gives the history of their development, their chemistry, physics, properties, applications and future possibilities.

Most prominence is given to "Neoprene" the American synthetic. This is not surprising because not only is it the only synthetic freely available in the world's markets but technical details of the manufacture of the other synthetics such as "Buna" and "Sovprene" have not been publicly disclosed. The book includes nevertheless much if not all the authentic information available on the synthetics of European origin and full references to published literature are given throughout in the text.

The author has succeeded in the difficult task of writing on a complicated chemical and physical subject in a way which appeals to both the technical and the non-technical reader. There is nothing to which the trained chemist can take exception and the non-technical person, while necessarily taken out of his depth in certain parts, can nevertheless read the book and obtain a clear grasp of the subject. The economic, like the scientific, aspects of synthetics are discussed without bias; synthetics are not treated as a menace but rather as a complement to the natural product.

The book is most carefully written and it is deservedly successful.

E. R.

The Chemistry and Technology of Rubber Latex by C. Falconer Flint with a Foreword by Lieut.-Col. B. J. Eaton, 1938 pp. XX and 715 (*Chapman & Hall Ltd., London*), Price 42s.

Dr. Flint's book is based on a translation of a French work of the same title, by Georges Génin, which first appeared in 1934. Our knowledge of latex technology has increased very rapidly in the four years which have elapsed since the publication of the original French book, and records of these advances are widely scattered in the patent and scientific literature. Dr. Flint has evidently made a thorough study of these sources of information, and the knowledge so acquired, together with his own valuable experience as a Research Officer of the Rubber Research Institute in Malaya, and with the Rubber Research Laboratories of Imperial Chemical Industries Ltd., in England, have been employed to good effect to amplify and bring up to date the translation of Génin's book. The result is essentially a new book which is almost twice the size of the original. The additions are not confined to one particular topic, but nearly every section has been enlarged.

To readers in the Far East the first 230 pages, which are divided into five chapters covering the source, composition and properties of latex, the coagulation and preparation of rubber, and the preservation, concentration and shipping of latex, will be of major interest. The remainder of the book covers compounding, vulcanisation, and the manufacture of various types of products from latex. There are two chapters at the end entitled, "Physical Testing of Latex Rubber," and "Artificial Dispersions of Rubber."

A practising planter may perhaps find gound for criticism in the account of tapping systems and estate work, which is not quite up to date, but it must be remembered that few accounts of planting practice are published outside the producing countries, and the book is intended for latex technologists rather than for producers. The latter will however find the chapter on preservation, shipping and concentration of latex particularly useful. In this connection it is interesting to observe the emphasis the author lays on the necessity for large bulking equipment to ensure uniformity throughout a consignment. This is a point not always appreciated by estates when the export of latex is contemplated.

Dr. Flint is to be congratulated on having produced such a comprehensive but readable treatise. The book is improved by the provision of an index which was not contained in Génin's book, and also contains numerous references to the literature. It should prove useful to all who are concerned with the study or use of latex.

J. H. P.

Latex and Rubber Derivatives and their Industrial Applications Vols. II and III. by Frederick Marchionna (*The Rubber Age, New York*).

Volume I of this encyclopaedic work, published in 1933, is so well known that the new volumes, constituting a supplement to the original work, will immediately commend themselves without comment to all rubber technologists. The new volumes preserve the highly acceptable format of the original work. The subdivision into chapters follows the same general lines, though the great developments in latex technology in recent years have necessitated the splitting of certain of the original chapters into a number of new ones, and the introduction of new subject headings. The type, the same as that used in the original volume, is notable for its easy legibility—a particularly valuable feature in a work of this kind—while access to any desired item amongst the great mass of material presented is rendered easy by the admirable series of comprehensive indexes.

A new feature which will be greatly appreciated is the supplementing of Mr. Marchionna's own admirable introductory remarks to selected chapters by a series of articles contributed by acknowledged experts in the field concerned. The names of these contributors—Fisher, McGavack, Schidrowitz, Twiss, Szegvari, Beal, Richter and Schur, Sebrell and Morris—speak for themselves. It is doubtless due to the limited space at his disposal that Dr. Fisher's contribution on "The Composition and Structure of the Rubber Hydrocarbon" deals somewhat summarily with subjects which are surely still open to discussion, *viz.* the molecular weight and the geometrical configuration of the rubber hydrocarbon.

Those working on the production side of the industry will naturally regret the curtailment in the new volumes of the chapters dealing with their own aspect of the subject (matter dealing with the production of latex for export now occupies only 146 pages out of a total of 1,432 as against 357 out of 886 pages in the original work), but this is doubtless inevitable in view of Mr. Marchionna's declared main purpose of comprehensively surveying the field of the *technology* of latex and rubber derivatives. For the same reason, much published work which the author regards as being of purely academic interest has been omitted; but the book nevertheless presents an excellent summary of much work of purely scientific import.

Unfortunately, or perhaps one should with respect to a work of this size say inevitably, a considerable number of minor typographical errors have crept in, but no serious blemishes have been detected.

The book is a splendid tribute to Mr. Marchionna's immense industry and to his fine critical faculty, which must have been almost constantly employed over a period of years in the production of this invaluable work.

K. C. R.

Manual of Rubber Planting (Malaya) Edited by A. T. Edgar, A.I.S.P. *(Published by The Incorporated Society of Planters, Malaya)*

Until this manual of Mr. Edgar's was published, only the R.R.I. publications and Rutherford's Planters' Note Book were available for use as text-cum-reference books.

This text-book, edited by a planter, Mr. Edgar, and published by the Incorporated Society of Planters, should be of valuable assistance to the Malayan planter. It is proposed to make this Manual serve the purpose of a text-book for those wishing to sit for the examinations of the Technical Education Scheme, sponsored by that Society. Young planters starting their career will find much food for thought in its pages and should, after mastering its contents, be well-equipped to carry out any job of work given them. Practically all the subjects likely to be encountered by the working planter are touched on in its pages and the information given is collected from authoritative sources.

There are two main omissions that might with advantage have been avoided, namely, estate schools and their management, and castes and customs of the Indian labourers employed on estates.

The book is divided into several parts, as follows:

Part 1

Section 1. This consists of Land Tenure, Choice of Land when Opening up an Estate, and contains much valuable advice both to the learner and the older planter.

On page 22, Mr. Edgar states that "labourers should not be allowed to burn off standing lalang, except perhaps in a very limited area which is going to be dug over immediately afterwards. Burnt lalang seeds again with embarrasing rapidity and the seeds will blow all over the area and cause much trouble by germinating and growing where land is supposed to be clear of this weed." This point does not seem to be fully realized by planters, as many areas can still be seen where the point is being neglected and serious trouble and expense can therefore be anticipated at a later date.

Costs are given for opening-up work, and although these are bound to vary between districts, they should be of assistance to planters when negotiations are proceeding with contractors.

Section 2. Cover Crops. Under this heading, certain points call for attention.

Page 29. Indigofera endecaphylla. It is stated that "drought causes it to brown off, but it quickly recovers. The plants are liable to attack by the larvae of a small moth, but damage is not permanent." This is not the general experience, as this cover after browning off very often does not recover and is therefore a danger from the point of view of fire. Further, in many cases this plant when attacked by the larvae of the moth does not refoliate and serious erosion occurs, especially on steep land. Moist conditions are really most suitable for the establishment and maintainance of this cover.

Page 29. Desmodium ovalifolium. This cover needs controlling, especially during early stages, if it is planted along the rows of rubber, as it will steal the manure that is being applied to the rubber plants.

It must, therefore, be kept back to at least a 6" diameter ring from the rubber.

Page 30. Mr. Edgar rightly advocates mixing one's cover-crops when planting but he gives no indication as to the proportions of the mixture.

Pueraria is a very expensive cover, the present price being around $180/- per picul, and therefore large quantities of seed cannot be economically put down.

Economical mixtures are as follows:—

Centrosema	*Pueraria*	*Calopogonium*
3	1	3
5	1	5

About 10-12 lb. of mixed seed are necessary for one acre.

Page 32. Digging in Covers such as Centrosema & Pueraria.

Another method that cheapens costs is to spray the covers first with a two-per-cent solution of sodium chlorate. This chemical browns off the cover and it is then easy to dig it in.

The reviewer found that, by using this method, it was possible to halve the cost of digging-in, as compared with digging covers without any previous treatment. It cannot yet be taken as generally established that digging-in of covers is a desirable practice.

Page 34. Line 25. "Further, it should be remembered that a bushy cover killed by root disease is easily seen and serves to

indicate the presence of a disease centre." In many cases this indication comes too late and the rubber, on inspection, is found to be affected by root disease, while the bushy covers are still flourishing. It is therefore essential to carry out the recommendations of the Pathology Division of the R.R.I. of Malaya and inspect the rubber early and regularly and not wait for the covers to indicate the presence of disease.

Further, a point worth mentioning under Bushy Covers is this, that careful supervision should take place to see that the roots of the bushy covers are not entering the planting holes and competing for the manures.

Page 37. Mr. Edgar states, "the best time to slash covers is when they are flowering." In practice, it is generally found that the best periods are March—April and October—December, as during these periods of wet weather the loppings will decompose more quickly and there is no danger from fire. Lopping should not be done in the dry weather, as the shade of the bushy covers is required to help keep the soil cool.

Sections 3 & 4. Planting & Budgrafting. In these sections can be found all the available data required by the planter and they are worthy of careful study.

Sections 5, 6 & 7. Seed Selection and Breeding, Maintenance of a Young Clearing, and Tapping give a very clear idea of the methods at present advocated.

Mention might, perhaps, have been made of the peculiarity of AVROS. 49 which tends to cause a lot of trouble in the early stages of tapping through premature coagulation.

Further, no mention has been made of the fact that, owing to the lack of a thick outer corky layer on the bark of budded trees, it is essential to fix the spout in position first, before cutting the spout channel. This is important and adherence to this practice will save much spout-wounding.

Sections 8—12. Important advice is given under these sections which should be read carefully by all.

Part 2.

In this portion of the book Mr. Edgar gives instructive details on Estate Management, Health Measures, Road Making and Malayan Timbers, and many useful tips can be culled from the various chapters.

Mr. Edgar wisely realised that a book such as this can never be up-to-date and he has, therefore, arranged for loose-leaf pages to be inserted at the end of each section. It will thus be possible

for further information to be collected, from time to time, and this can be passed to purchasers of the Manual, so that they will be able to feel that they are keeping in touch with current planting practice.

The book has been edited by a planter, for planters, and wherever possible technical terms have been excluded or are fully explained. That it is a valuable contribution to the literature of rubber planting is, I am sure, acknowledged by all who have read the Manual.

H. W. F.

A Note-Book of Tropical Agriculture Compiled by R. Cecil Wood, M.A., DIP.AGRIC. (Cantab.) (*Published by the Imperial College of Tropical Agriculture, Trinidad, B.W.I.*)

Chapters 1—9

In this small book of reference Professor Cecil Wood has amassed an amazing amount of interesting information on Tropical Agriculture. The first part of this book deals with Weights and Measures, Mensuration and Surveying, and Buildings and Roads, and much useful data is available for the reader's information.

The chapter headed Machinery deals briefly with Internal Combustion Engines, Electricity, Tractors, Centrifugal Pumps and Hydrams, and the various tables should prove of assistance to any one contemplating using such machinery.

A brief summary of the various tasks that can be done per day by a labourer carrying out the daily routine on an Agricultural Station are given.

Soils, Manures and General Agricultural Crops are next dealt with in terms that can be clearly understood by the layman. The chapter on Soils gives details of soil classifications, climatic classification in to Soil Regions, and a table shows examples of Humid Tropical Soil Profiles.

Crop Ecology is also dealt with under this heading, such important factors as static factors and dynamic factors being clearly explained.

Instructions for the planting of Cereals, Pulses, Root Crops, Vegetables, Oil Seeds, Fibres, Condiments, Flavours etc., are given and the amount of seeds required per acre are shown. Under this heading details of the preparation of Dyes, Tans, Sugar, Rubber, Beverages (coffee, tea and cocoa) are also given.

Oil palms are briefly touched on and the chapter concludes with information about the various tropical fruits grown; a set of

tables giving details of Foods and Feeding is to be found on pages 87-98.

Chapter 10

This chapter deals with Live Stock in general, and details of Breeding, Rearing, etc. are given.

A table on page 105 gives details of the gestation period for calving. Cattle, Sheep, Goats, Swine and Poultry are discussed and tables are added showing various forms of preservative for keeping eggs, and a list of medicinal substances and instruments is given, which it is emphasised should always be at hand where stock are kept.

Chapters 11 and 12

This chapter deals with Dairying, and in chapter 12, Recipes are given for various Insecticides, for making Grafting Wax, Preserving Leather and Skins.

Chapters 13 and 14

This chapter deals with Statistics and formula are available for those readers interested in this subject.

In Chapter 14, a table of Current Prices for Agricultural Products is given, and the book concludes with an excellent Index.

This book which is produced in pocket form should be of considerable assistance as a book of reference to those dealing with Agricultural problems, and well repays study.

H. W. F.

Annual Bibliography of Rubber Literature (excluding Patents) 1937. (*The Rubber Age*, New York).

This remarkably compact little volume follows the same lines as in previous years and continues to be notable for the ease with which any desired reference to rubber, either technological or academic, during the period under consideration, may be traced. A cursory examination reveals that the compilation is remarkably complete. It should prove, as heretofore, a most valuable aid to all whose work lies in the sphere of rubber.

K. C. R.

SOIL EROSION

Some recent Publications

During recent years there has been no lack of literature on the subject of soil erosion. It has poured in from all sides, more particularly from the United States of America and from those parts of Africa which have not yet been reduced to deserts. Wherever the authors have gone beyond the purely technical aspects of the subject, the story is always the same. The causes and effects of soil erosion are well known, and the principles of conservation are generally understood and agreed upon. The terrible menace of soil erosion is apparent to all scientific workers on the land, and to all intelligent lay observers. But the average tiller of the soil is still ignorant and apathetic, whilst legislative authorities are too complacent and too slow in taking effective action.

Whether we like to think it or not, we all live on the products of the top few inches of soil. This is slipping into the rivers and oceans at the rate of *hundreds of million tons each year*. When it is gone, we too must go, unless we can find some means of subsisting on inorganic matter and sea-food. It takes perhaps 10,000 years for Nature to build up a foot of soil. Under clean cultivation, on an unprotected slope as gentle as 1 in 12, this is often washed away in less than half-a-lifetime. We in Malaya are affected not merely as rubber-growers, but as members of an earth-bound race who cannot live without eating.

The difficulty in arousing a widespread demand for effective action against soil erosion seems to lie in the fundamental fact that in general a man does not himself suffer greatly from the erosion which he causes or permits. So long as a man can make a living out of a piece of ground, he does not much care if the ground is finished when he is. He is not inclined to make work for himself by demanding anti-erosion measures which he would have to practise, whilst the general public and the law-makers do not realise the seriousness of the problem. Fortunately there are signs of a change in this attitude, and in most countries which are subject to severe erosion a start has been made to conserve the soil. Much more remains to be done, by official action to compel soil conservation and by propaganda to make such compulsion acceptable. It may be comforting to reflect that there is still enough soil to grow all the food we shall need in our lifetimes, but those who have contributed to posterity, and feel a duty towards it, should arouse themselves to prevent the present colossal rate of wastage of the medium from which our means of life are obtained. Otherwise their instinctive or dutiful

biological efforts to secure the continuance of our race will be doomed to frustration through agricultural carelessness.

Conservation of the Soil BY A. F. GUSTAFSON, *303 p.p. and Index. (Mc. Graw-Hill Book Co., New York and London)*

In this book Professor Gustafson, of Cornell, describes in a very readable fashion the causes, effects, and methods of prevention of soil erosion. It is written with particular reference to the erosion problems which have arisen on the vast farm lands of the United States of America, but as the primary causes of soil erosion, and the main principles of soil conservation, are the same everywhere, this excellent book could be read with interest and advantage by anyone. Although suited to the general reader it is not merely an "elementary" or "popular" book, and the serious student will read it with profit. It is mainly technical, but the social implications of soil erosion are not neglected.

The book contains over 30 tables, and is very well illustrated with no less than 195 pictures or diagrams in its 303 pages. The pictures alone are almost enough to tell the story, which the text amplifies.

Soil Erosion and its Control BY QUINCY C. AYRES, *352 p.p. and Index. (McGraw-Hill Book Co., New York and London)*

This book by Prof. Ayres of Iowa State College was first published in 1936. It was then the most comprehensive book on soil erosion in existence, and still appears to be so. It has much in common with the more recent book by Prof. Gustafson, reviewed above, but deals in greater detail with the various aspects of erosion and with the technique of soil conservation. It is equally lavishly illustrated and also contains much tabulated information. A useful appendix contains details of simple methods of calculating land areas, lists of plants arranged according to their influences on erosion, and two mathematical tables. An extensive bibliography is also included.

This book is better suited to the student and agricultural worker than to the general reader.

Erosion and Soil Conservation BY G. V. JACKS AND R. O. WHYTE; *Imperial Bureau of Soil Science, Technical Communication No. 36, 206 pp.*

This publication is essentially a very useful bibliography of all the important literature dealing with soil erosion in all countries about which information was available. It does not set out to give technical instruction on soil conservation, but describes the present position in a general way. As might be

expected in a publication of this sort, the perspective is not always well balanced, and its greatest value is in its comprehensive lists of references.

Soil Erosion in the Colonial Empire BY SIR FRANK STOCKDALE, *Empire Journal of Experimental Agriculture, Vol. 5, p.p. 281-297.*

In this article Sir Frank Stockdale, the Agricultural Adviser to the Secretary of State for the Colonies, surveys briefly the present position with regard to soil erosion in the British Crown Colonies and Dependencies. The chief factors contributing to soil erosion in each country are stated, the attempts to improve matters are outlined, and the directions in which further efforts are needed are indicated. The article points out the urgency of immediately tackling the problem of soil erosion, and thus should be of interest to Malayan administrators and agriculturalists who, in the near future, will probably be obliged to realise the necessity of enforcing more serious preventive measures in this country.

Soil Erosion A MEMORANDUM BY E. HARRISON, DIRECTOR OF AGRICULTURE, TANGANYIKA, *for Official Use, 21 p.p. (Crown Agents for Colonies, London)*

This Memorandum refers particularly to the efforts being made to combat soil erosion in Tanganyika, and thus as regards technique and practice has little bearing on the erosion problem in Malaya. It is, however, interesting for its clear exposition of the policy to be pursued to make the general public conscious of the seriousness of erosion and to ensure willing co-operation in large-scale effort. This policy is conveniently summed up in the following extract (p. 5):—

> "This decision (first to create favourable public opinion for the "prevention of erosion) required that field officers of the Agricultural, "Forestry and Veterinary Departments should first carry out pro- "paganda and should demonstrate the proper management of land and "the measures necessary to minimise loss of soil by erosion. Officers "of the Department of Education were to include the subject in the "school curriculum, both within the class-room and in the school "gardens; the latter everywhere should demonstrate anti-erosion lay- "out Forestry officers should encourage the planting of wind-breaks "and wood lots where necessary; they were to impress on the people "the need for the preservation of the natural forest growth and "vegetation on the crests and steep slopes of hills and along water- "courses. Veterinary officers should point out the risks of over- "stocking, the value of rotational grazing, the utilisation of plant "residues as stock food and the value of multiplying watering-places "for stock. Officers of the Public Works Department and the Rail- "ways were requested to see that water collecting in their roads and "railways was disposed of in such a way as not to create erosion

"below; the alignment of new roads was to be considered in relation "to the general problem. Agricultural officers were instructed to "demonstrate and preach the value of soil cover, planting and cultivation "on the contour, the use of terracing and anti-erosion banks, contour "weed lines, contour strips of undisturbed land, protection of trees "and so forth."....."All these efforts were to be focussed by "administrative officers, who were, in every way possible, to bring "clearly to the notice of the people the real meaning of erosion and "the worth of the efforts of the individual cultivator."

A. M.

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